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#176 JANUARY 2020

Sky at Night

THE UK'S BEST SELLING ASTRONOMY MAGAZINE

2020's UNMISSABLE NIGHT SKY

The top 20 sights to observe in the New Year, including

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High & bright at opposition

STELLAR CHALLENGE

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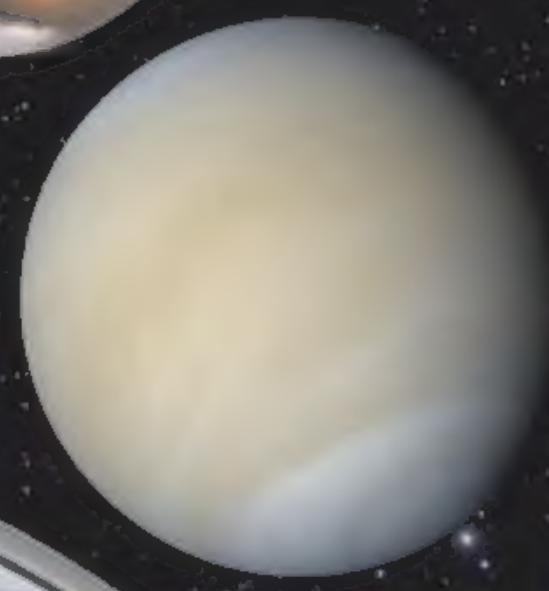

VENUS
A beautiful Evening Star

JUPITER & SATURN
Together in a dramatic 'Great Conjunction'

BUZZ AT 90
Exclusive interview inside

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Royal Astronomical Society's milestone

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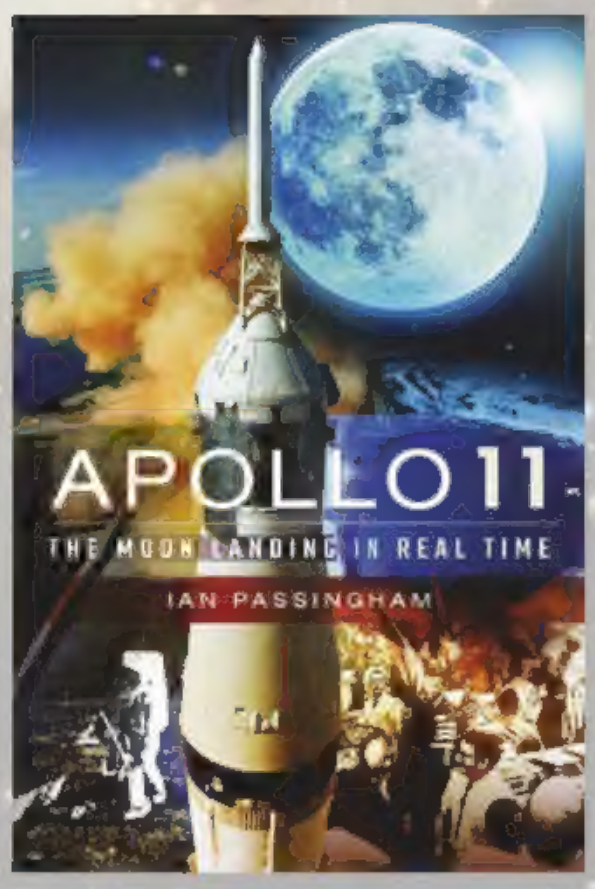

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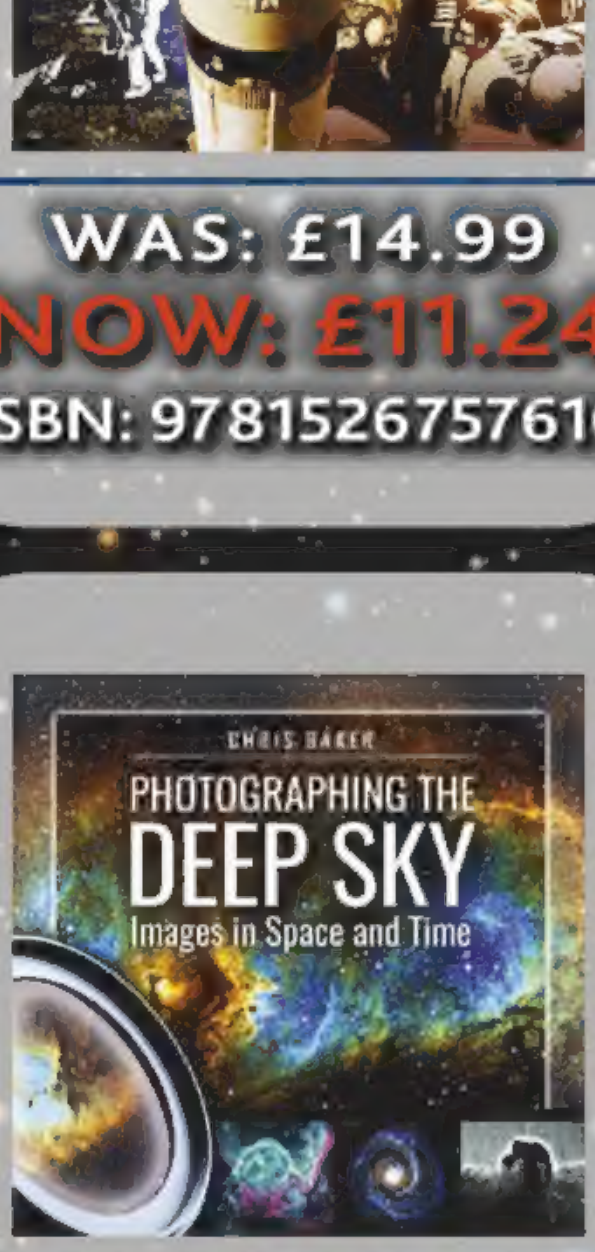

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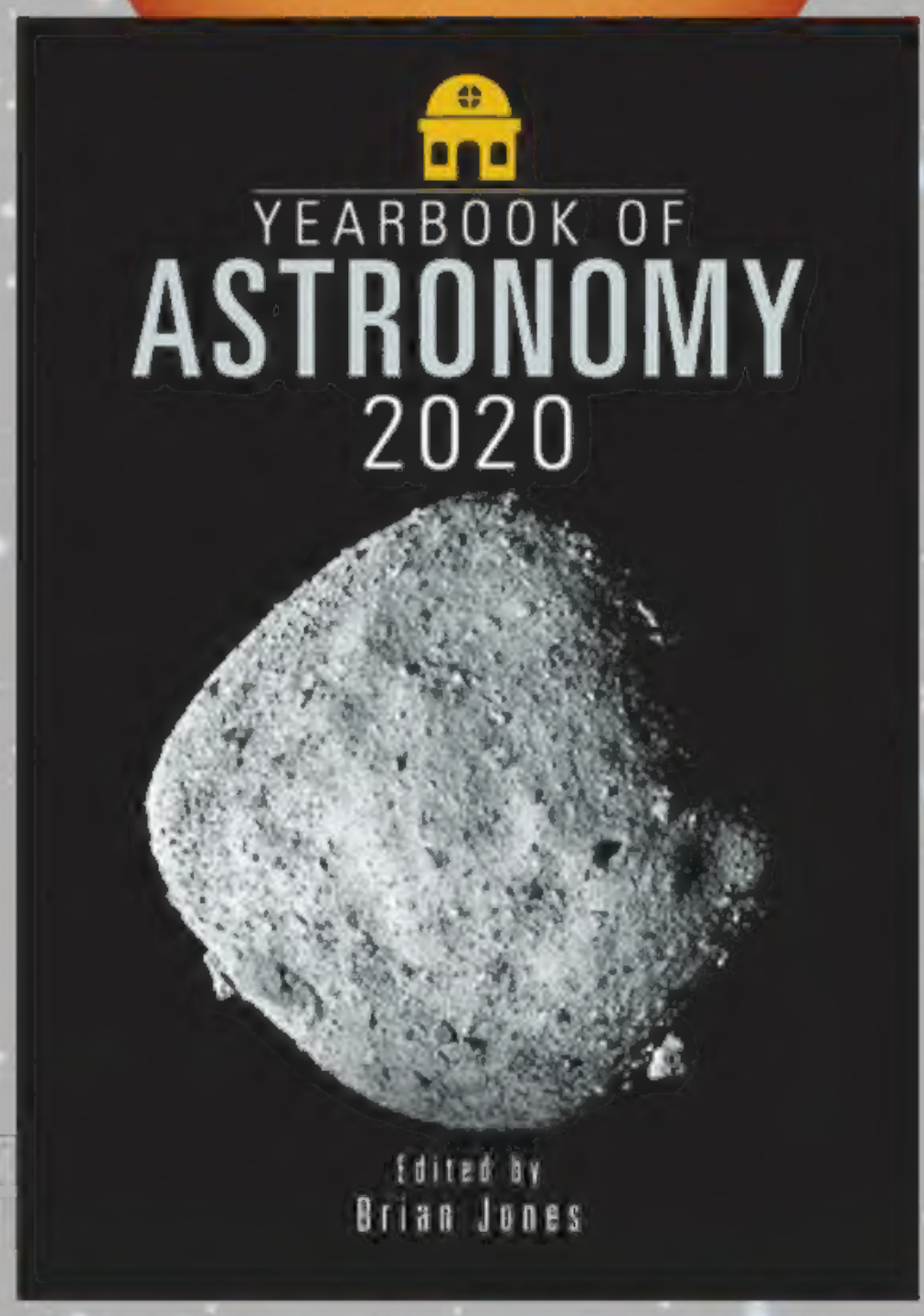

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Welcome

Join our tour of the greatest stargazing sights of 2020

The first year of the new decade is shaping up to provide some vintage stargazing opportunities. The planets provide much excitement in the coming 12 months: there's a lovely apparition of Venus in the first half of the year and Mars begins to take centre stage in the summer, leading up to a fantastic opposition in October – this could be better even than the last opposition of 2018, when Mars and Earth were at their closest. Mary MacIntyre looks ahead to more great sights to observe in the New Year on page 30, including a 'Great Conjunction' of Jupiter and Saturn at Christmas next year.

Talking of great sights to observe each month, I have some news about our Virtual Planetarium. Our interactive video of the month's night-sky highlights, which is online at **skyatnightmagazine.com**, has been audio-only for the past few months. But from this month we're proud to present it as an all-new experience, in which the celestial commentary from Pete Lawrence and Paul Abel is paired with fully realistic video views of the night sky. It makes fantastic viewing and I encourage you to visit our website and see for yourself.

Many of you have been in touch over the past six months asking about the packaging in which we send out our subscriber copies. The good news is that from this issue all subscriber copies will be posted in paper wrapping instead of recyclable plastic polywrap. The wrapping is made from sustainably sourced paper and is 100 per cent recyclable, so it can be put in your recycling bin. If you have any feedback, please contact us at **paperwrap@immediate.co.uk**; we'd love to hear your views.

Enjoy the issue and Happy New Year!

Chris Bramley, Editor

PS Our next issue goes on sale 23 January.

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30

CONTENTS

C = on the cover

Features

Regulars

Astrophotography

Reviews

The Sky Guide

New to astronomy?

To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners

This month's contributors

Rod Pyle

US author and space journalist

As Buzz Aldrin reaches 90, Rod reveals how his passion for space remains undimmed. See page 36

Katrin Raynor-Evans

Astronomy writer

Katrin looks back at 200 momentous years of the Royal Astronomical Society. See page 66

Ben Evans

Space historian

Ben explores the groundbreaking infrared legacy of the Spitzer Space Telescope. Turn to page 60

Siân Anna Lewis

Travel writer and blog editor

As winter is upon us, Siân samples the best clothing options for long nights of stargazing. See page 72

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/Z2YBKVM/** to access this month's selection of Bonus Content.

JANUARY HIGHLIGHTS

The Sky at Night: A Comet's Tale

Chris Lintott reports live from ESA's HQ in the Netherlands as the Rosetta mission comes to end.

Video interview: ExoMars rover

Prof Andrew Coates of UCL reveals how one of 2020's biggest missions will scour the Red Planet searching for signs of life.

Audiobook: RS Ball's Christmas lecture

Listen to a chapter about Robert Stawell Ball's 1881 talk on the Sun, Moon and planets, delivered at the Royal Institution.

The Virtual Planetarium returns!

Watch our new and improved interactive guide to the month's night-sky highlights, with Pete and Paul.

A speck on THE SUN

A tiny black spot in the corona of the Sun, Mercury completes its 5.5 hour pass across our star's disc

SOLAR DYNAMICS OBSERVATORY, 11 NOVEMBER 2019

Roughly one-third the size of Earth and 280 times smaller than the Sun, our Solar System's most diminutive world is dwarfed as it completes the fourth of its 14 solar transits this century – moments when, from our perspective here on Earth, Mercury and the Sun are exactly in line. This is the last such crossing until 13 November 2032.

Comparisons of these pictures from NASA's Solar Dynamics Observatory with images from 2016's transit show the planet as an even tinier spot this time, reflecting the fact that Mercury was approaching its perihelion and further from Earth.

A more obvious contrast with 2016 is the Sun's comparatively featureless surface. Essentially an electrically-charged ball of hot gas, the Sun's activity fluctuates over each 'solar cycle', a period of around 11 years during which its magnetic field flips and its north and south poles switch places. Our star, currently in the closing stages of its 24th solar cycle, is going through one of the most prolonged periods of weak activity since accurate records began in 1755, producing little in the way of sunspots and flares.

MORE ONLINE
A gallery of these and more stunning space images

COURTESY OF NASA/SDO AND THE AIA EVE AND HMI SCIENCE TEAMS

△ Black hole oddity

CHANDRA X-RAY OBSERVATORY, HUBBLE SPACE TELESCOPE, VERY LARGE ARRAY, 18 NOVEMBER 2019

Supermassive black holes, found at the centre of galaxies, normally stifle star formation, keeping gases too warm for stars to form. But this weakened black hole in the centre of the Phoenix Cluster, in the Southern Hemisphere constellation of Phoenix, is believed to be not just allowing but boosting star formation at the cluster's heart – the first clear indication that black holes can enhance cooling.

▽ Star factory

HERSCHEL AND PLANCK SPACE OBSERVATORIES, 18 NOVEMBER 2019

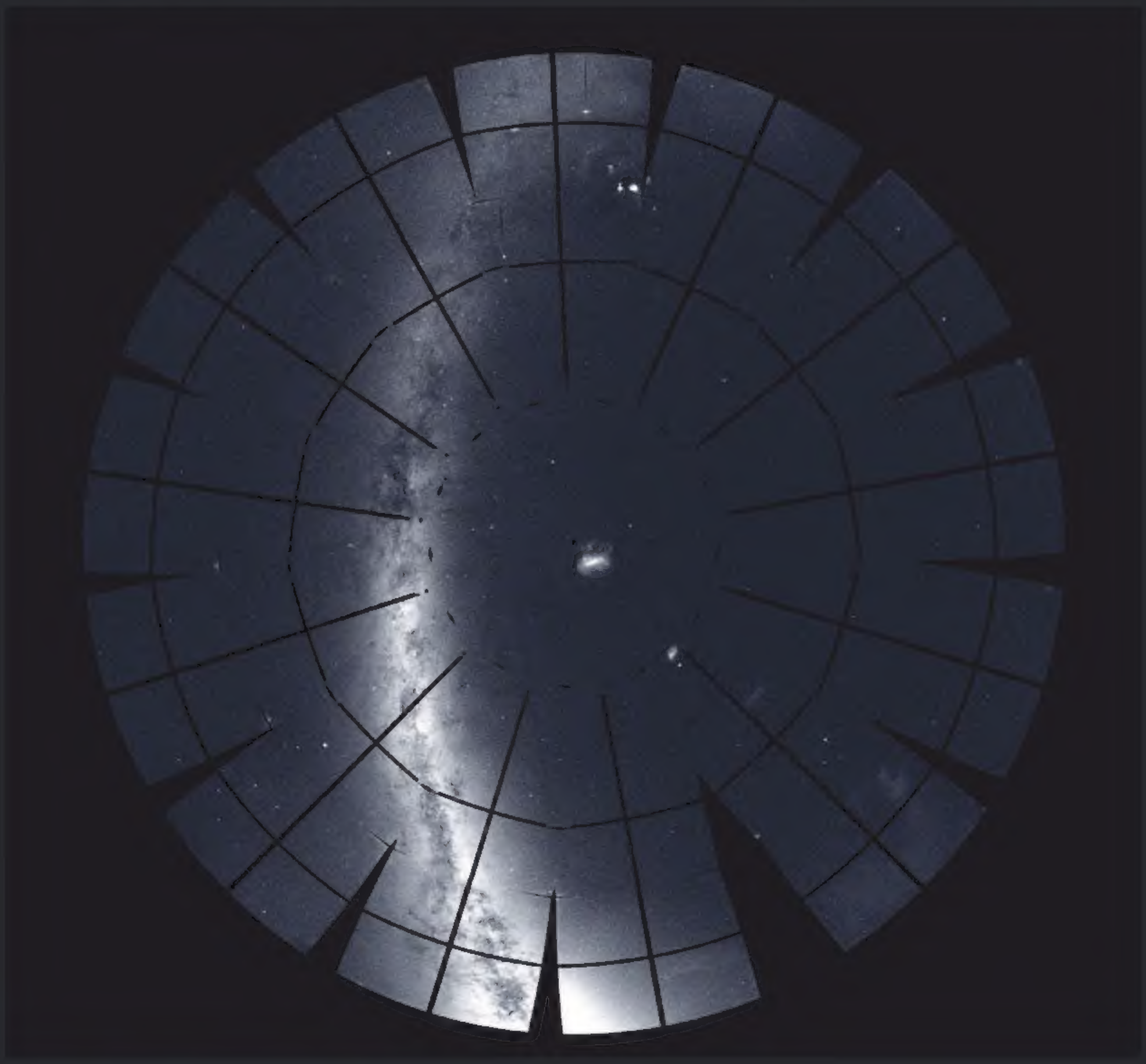
A vast cloud 1,350 lightyears away in the constellation of Orion, Orion A is packed full of star-making gas and dust. The colours in this infrared image indicate the light emitted by interstellar dust grains mixed within the gas, while the faint grey bands show the magnetic field's orientation. This recently released image uses data from the Herschel and Planck space observatories, which operated until 2013.

NASA/CXC/MIT/M.MCDONALD ET AL/NRAO/VLA/STSCI, ESA/HERSCHEL/SOLER/MPIA, ESA/HUBBLE & NASA/K. LARSON ET AL, NASA/MIT/TESS

Dynamic duo ▷

HUBBLE SPACE TELESCOPE, 25 NOVEMBER 2019

This twisty character and straight sidekick are two spiral galaxies (the one on the right is viewed edge-on) called NGC 6285 and NGC 6286, near-neighbours 250 million lightyears away in the constellation of Draco, the dragon. Known together as ARP 293, the pair are interacting, their mutual gravitational attraction drawing wisps of gas and dust from each other, bending each out of shape in the process.

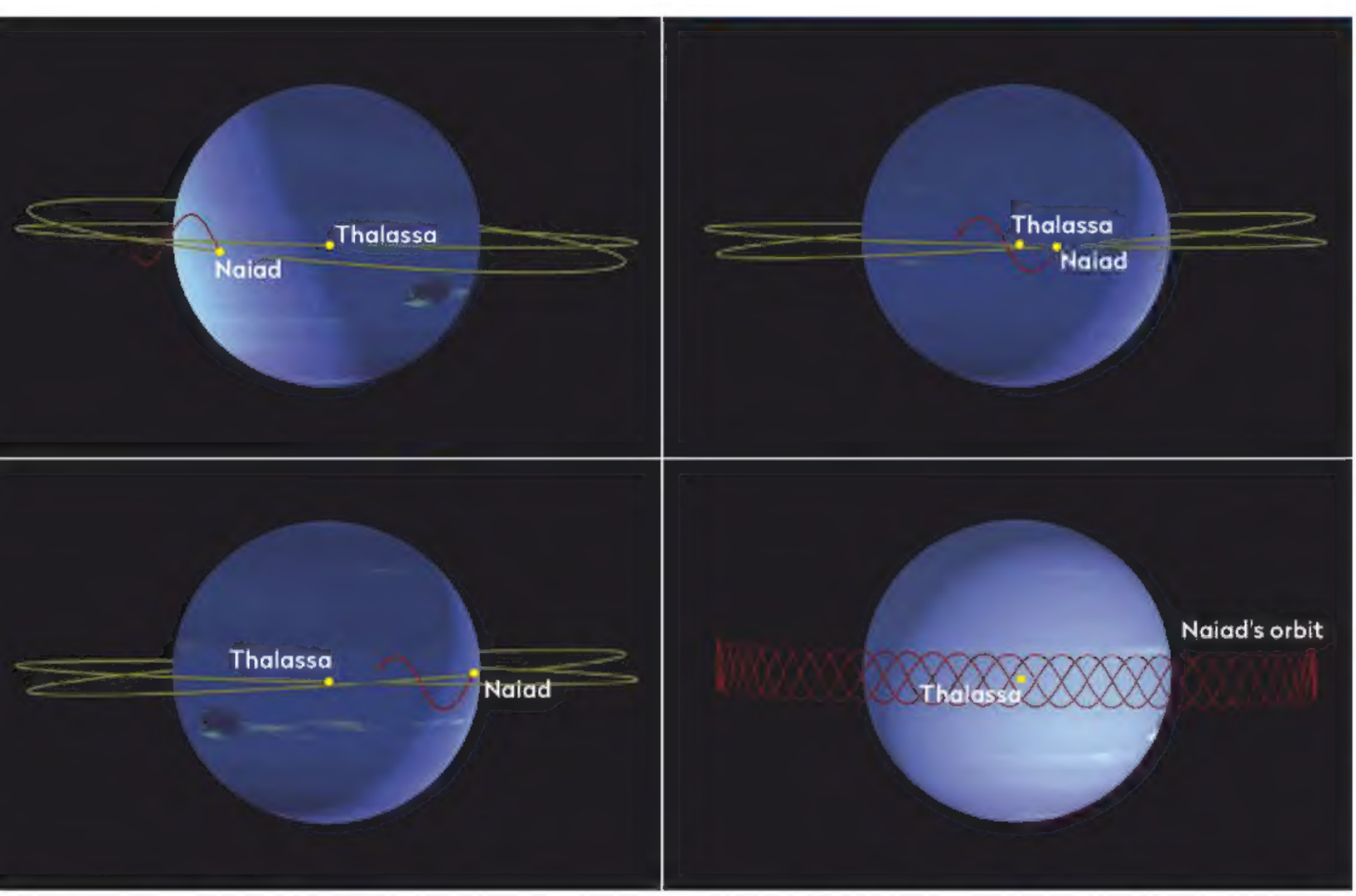


△ Southern sky panorama

TRANSITING EXOPLANET SURVEY SATELLITE (TESS), 5 NOVEMBER 2019

Assembled from 208 images taken over the course of a year, this mosaic captures the glowing Milky Way, the Orion Nebula (top) and the Large Magellanic Cloud (centre). TESS divided the Southern Hemisphere into 13 sectors and imaged each one for nearly a month using 16 charge-coupled devices (CCDs). Now in its second year of operation, TESS has turned its attention to the Northern Hemisphere.

BULLETIN



▲ **Odd couple: Neptune's inner moons, Thalassa and Naiad appear to have unusual orbits, but Naiad effectively dodges its partner with a zig-zag manoeuvre when the two small moons are close**

NASA/JPL-CALTECH X 4, NASA/JPL-CALTECH/ASU, NASA/JPL-CALTECH/SWRI/MSSS/KEVIN M. GILL, P WEILBACHER (AIP)/NASA/ESA/THE HUBBLE HERITAGE (STSCI/AURA)-ESA/HUBBLE COLLABORATION AND A EVANS (UNIVERSITY OF VIRGINIA/ CHARLOTTESVILLE/NRAO/STONY BROOK UNIVERSITY)

Neptune's marvellous moondance

The ice giant satellites' moves help keep them in a stable orbit

Two of Neptune's inner moons are locked in a celestial 'dance of avoidance'. Recent analysis of images taken by the Hubble Space Telescope found the orbit of one of the moon's drifts, meaning it passes further away from the other than it would otherwise.

Neptune, the furthest planet from the Sun, is home to 14 known moons, including the 100km-long Naiad and Thalassa. It takes Naiad just seven hours to orbit Neptune, while Thalassa takes 30 minutes longer. When they pass each other by, they should be just 1,850km away. However, Naiad's orbit appears to tilt back and forth. Every time it catches up with the slower moving Thalassa, Naiad's orbit has tipped away and the pair pass no closer than 3,540km from each other.

If you were standing on Thalassa, you would see Naiad go past at wildly differing inclinations, with two passes occurring above the moon followed by two below.

"We refer to this repeating pattern as a resonance," says Marina Brozovic from the Jet Propulsion Laboratory, who led the study. "There are many different types of 'dances' that planets, moons and asteroids can follow, but this one has never been seen before."

It's thought the moons fell into this pattern when Neptune captured the much larger moon, Triton, upsetting the gravitational balance of the planet's existing satellites.

"We are always excited to find these co-dependencies between moons," said Mark Showalter from the SETI Institute, who also took part in the study. "Naiad and Thalassa have probably been locked together in this configuration for a very long time, because it makes their orbits more stable. They maintain the peace by never getting too close."

https://hubblesite.org

Comment

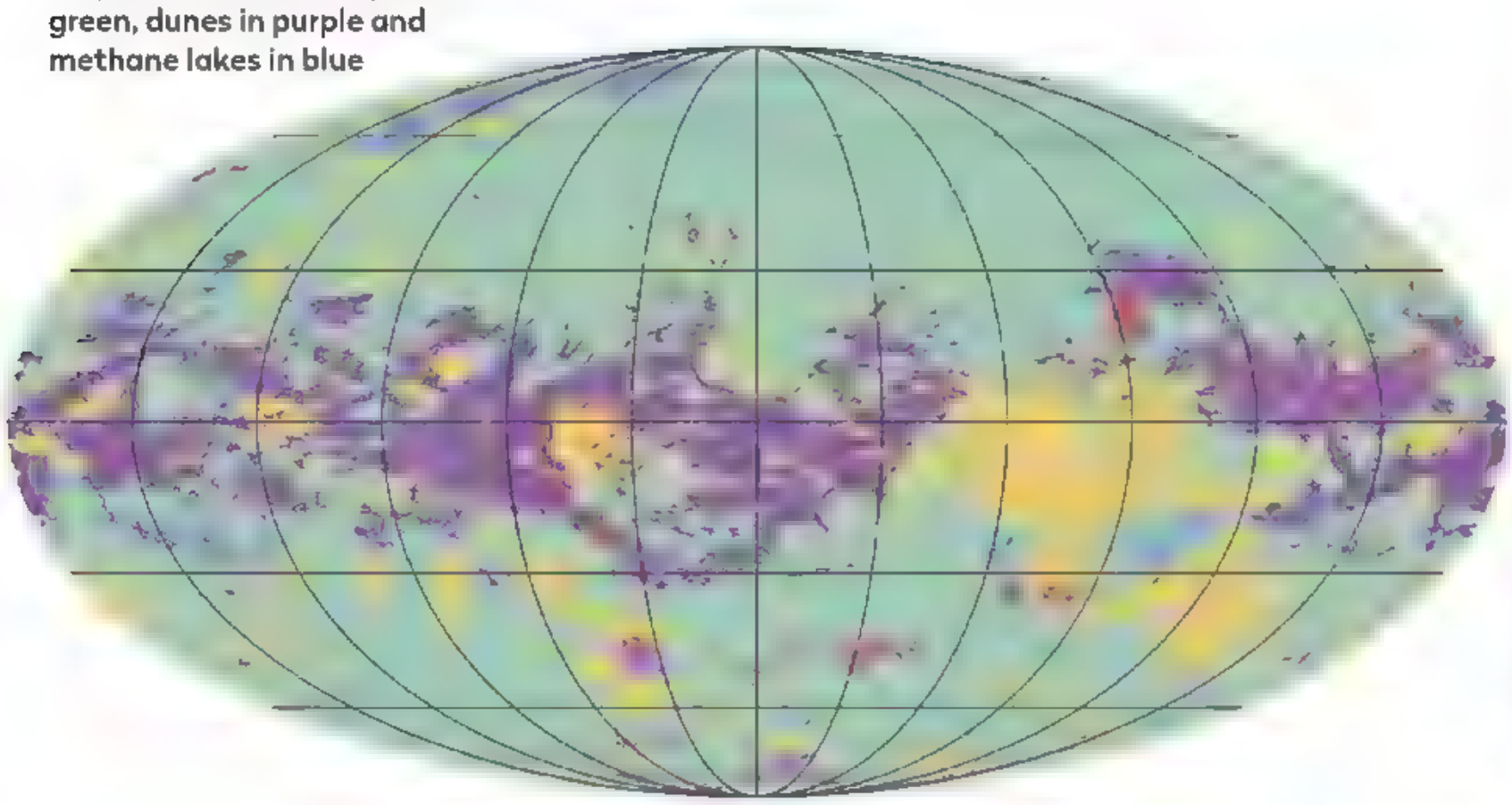
by Chris Lintott

The complexity of the patterns nature weaves through planetary dynamics is amazing. These systems pack so many objects close to their parent planet that interactions and resonances like those between Naiad and Thalassa must be all but inevitable. The same may be true for some of the exoplanet systems we've found, whose worlds crowd round their parent star.

Take K2-138, where five planets sit in a resonant chain, or the TRAPPIST-1 system, where seven planets jostle for space. Planets in such systems might one day be found to follow the same dance steps as Neptune's moons – and if they do, we will learn much about their life stories.

Chris Lintott co-presents *The Sky at Night*

▼ Moon safari: the first geological map of Titan includes plains in green, dunes in purple and methane lakes in blue



Map reveals terrain of Titan

Astronomers have first global view of moon's geology

Scientists have created a new geological map of Saturn's moon Titan, pieced together using data from NASA's Cassini spacecraft, which flew past the moon around 120 times. The spacecraft used radar and infrared imaging to pierce through the thick haze that surrounds the moon and pick out its geological features.

"Titan has an active methane-based hydrologic cycle that has shaped a complex geologic landscape, making its surface one of the most geologically diverse in the Solar System," says Rosaly Lopes from NASA's Jet Propulsion Laboratory, who led the research.

Despite the differences in materials, the map shows several familiar features found on our own planet. Around two thirds of Titan is covered in flat plains, though the equator is dominated by 100m high dunes, while lakes of liquid methane lie close to both poles.
www.nasa.gov

Great Red Spot still going strong

All the rage: there's still plenty of life in Jupiter's Great Red Spot

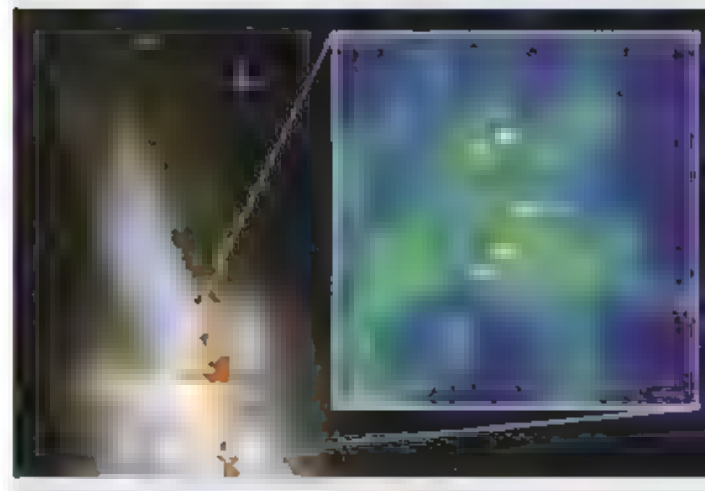
Reports of the Great Red Spot's (GRS's) death may have been greatly exaggerated. Though the visible spot might be shrinking, the vortex which drives it appears to be going strong, according to a recent study.

For over a century, astronomers have diligently studied the GRS, a giant storm on Jupiter, tracking its changing size and shape. In the last decade or so, astronomers have noticed the spot is steadily reducing in size. Then, in spring 2019, observers saw large 'flakes' of cloud breaking away from the spot, leading people to wonder if the GRS's end was near.

However, astronomer Philip Marcus from the University of California, Berkeley, has suggested that these flakes are actually just the natural product of the GRS bumping into smaller cloud formations, stripping off part of the cloud cover but leaving the main vortex untouched.

"The creation of little vortices to the east/northeast of the GRS during the spring of 2019, and the subsequent merging of the GRS with some [vortices], does not signify its demise," says Marcus.
https://www.berkeley.edu

NEWS IN BRIEF



Galaxy has black hole trio

ESO's Very Large Telescope has observed that galaxy NGC 6240 contains three supermassive black holes. The trio weigh 90 million solar masses and are probably the product of three galaxies merging. "Up until now such a concentration of supermassive black holes had never been discovered" says Peter Weilbacher from Leibniz Institute for Astrophysics.

TESS discovers an impossible planet

NASA's exoplanet-hunting spacecraft, TESS, has found a world that shouldn't exist. Using TESS data astronomers found a planet was so close to its red giant host star that it should have been destroyed by the star's expansion. Either the star is still ballooning or the planet's orbit has moved in and out as the star has grown – astronomers will study the system to find out which.

Runaway star spotted

ESA's Gaia satellite has observed a star hurtling through the Milky Way at 6 million km/h. Backtracking its path, astronomers found it had a close encounter with the Galaxy's supermassive black hole, which may have accelerated it.

Oxygen behaves curiously on Mars

The rover found the gas levels rise during the summer months

NASA's Curiosity rover has discovered that oxygen levels on Mars fluctuate with the seasons, but it changes in a way which planetary scientists are struggling to explain.

The Martian atmosphere is 95 per cent carbon dioxide with only 0.16 per cent oxygen. However, when one of the poles is in winter, it gets so cold that the atmosphere in the region freezes to form a carbon dioxide ice cap, lowering the air pressure. In the spring and summer, the ice cap thaws and the pressure rises again.

While other gases in the atmosphere, such as nitrogen and argon, follow a predictable pattern of changing concentration to match this shift, the oxygen does not. After three years of measuring the atmosphere with its Sample Analysis at Mars (SAM) instrument, the rover has discovered that every spring and summer the oxygen levels rise by 30 per cent, before falling again when autumn rolls around.

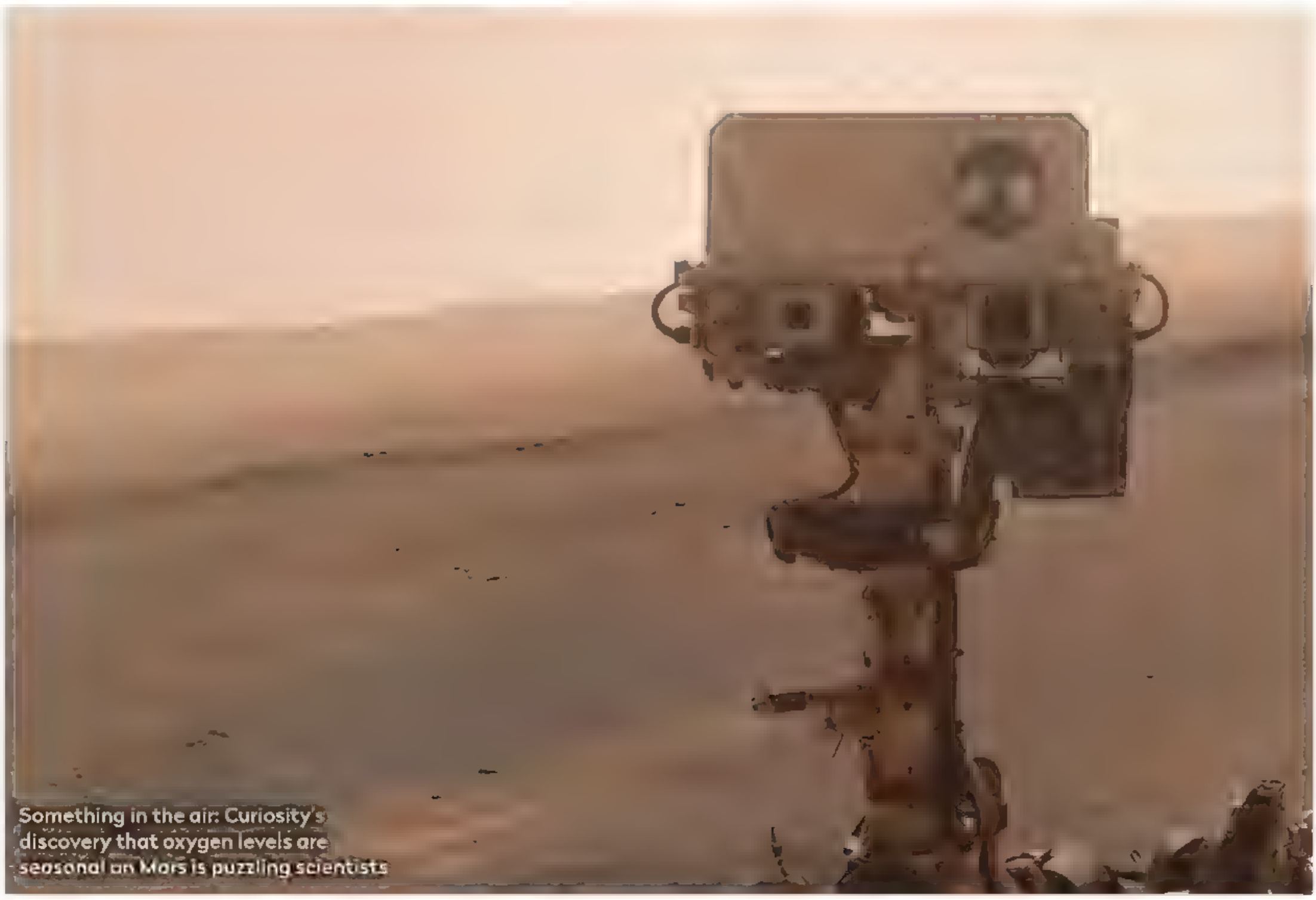
"We have not been able to come up with one process yet that produces the amount of oxygen we need, but we think it has to be something in the surface soil that changes seasonally because there aren't enough available oxygen atoms in the atmosphere to create the behaviour we see," says Timothy McConnochie from the University of Maryland, US, who helped with the research.

Curiosity has spotted a similar pattern in the levels of Martian methane, hinting that the two may be related. As both gases are related to life on Earth, the find has excited those hoping to find extant life on Mars, but most think that a more mundane, geological process is more likely.

"We're struggling to explain this," says Melissa Trainer, from NASA's Goddard Space Flight Center in Maryland, US who led the research. "The fact that the oxygen behaviour isn't perfectly repeatable every season makes us think that it's not an issue that has to do with atmospheric dynamics.

"This is the first time where we're seeing this interesting behaviour over multiple years. For me, this is an open call to all the smart people out there who are interested in this: see what you can come up with."

https://mars.nasa.gov



NASA/JPL-CALTECH/MSSS, ESA/HUBBLE/NASA/RIVERA-THORSEN ET AL

Something in the air: Curiosity's discovery that oxygen levels are seasonal on Mars is puzzling scientists

Hubble captures a galaxy duplicated a dozen times

Newly released images from the Hubble Space Telescope have captured a galaxy that's been duplicated 12 times by gravitational lensing. The light from the galaxy, nicknamed 'Sunburst Arc', passes by a larger galaxy on its way to Earth, bending the light as if it had passed through a lens.

The galaxy is 10 to 30 times brighter thanks to the lensing; it is what makes Sunburst Arc, located 11 billion lightyears away from Earth, bright enough to see with the Hubble Space Telescope. However, it also distorts and duplicates the image many times over.

Sunbust Arc is very similar to galaxies from a much earlier time, just 150 million years after the Big Bang, known as the epoch of reionisation. Hubble's observations will help give insight into this key era of the Universe.
https://spacetelescope.org

NEWS IN BRIEF

UPDATE: Comet Borisov

Interstellar comet 2I/Borisov is still speeding its way through the Solar System. In late November, its tail was nearly 160,000km long, 14 times the diameter of Earth, with a nucleus just 1.5km wide. The comet is due to make its closest approach to Earth in late December.

Hayabusa 2 heads home

Japanese asteroid explorer Hayabusa 2 left its asteroid on 13 November 2019, beginning the year long journey back to Earth. The spacecraft is hopefully carrying several samples of rock from the surface of asteroid Ryugu, where it has been since June 2018. The spacecraft will return to Earth in December 2020, allowing geologists around the world to study its cosmic cargo.

Ultima Thule's new name

The Kuiper Belt object visited by NASA's New Horizons spacecraft on New Year's Day 2019 has been given the official name Arrokoth. The name means 'sky' in Powhatan, the language of the Native American people who lived in Maryland, where the New Horizons' mission control is based. It had previously been called 2014 MU69, though was commonly nicknamed Ultima Thule.

PIETER VAN DOKKUM/CHENG-HAN HSIEH/SHANY DANIEL/GREGORY LAUGHLIN, KAGOSHIMA UNIVERSITY, ESA/S CORVAJA, NATIONAL INSTITUTE OF POLAR RESEARCH

BULLETIN

Black holes could have planets

Thousands of worlds may orbit around a galaxy's centre

An artist's impression of planets orbiting a black hole

The black holes at the centres of most galaxies could host thousands of planets, according to a new paper.

All currently known planets orbit around stars, having grown out of the surrounding disc of dust known as a protoplanetary disc. However, supermassive black holes also have debris discs, but which hold several billion times more material.

"Our calculations show that tens of thousands of planets with 10 times the mass of Earth could be formed around 10 lightyears from a black hole," says Eiichiro Kokubo from the National Astronomical Observatory of Japan, who took part in the study. "Around black holes there might exist planetary systems of astonishing scale."

Although there is currently no way to detect these potential planets the study could open up a whole new field of astronomy.

www.nao.ac.jp/en/

ESA receives blockbuster budget

The European Space Agency (ESA) approved its vision for the next three years at a triennial ministerial meeting held on 27-28 November. The meeting began with the member states agreeing to give the agency €12.5 billion over the next three years – ESA's largest budget to date.

▲ **Great expectations: the European Space Agency has been granted a budget of €12.5 billion, its largest to date**

Much of this will be spent on Earth observation projects, giving Europe the tools to become a global leader in tackling the climate crisis. Meanwhile, in ESA's science and exploration wing LISA (Laser Interferometer Space Antenna), a gravitational wave observatory; Athena, a black-hole hunter mission and a new lunar landing mission have all been given the go ahead.

ESA also plans to take part in several joint ventures with NASA. Hera will team up with the US's DART mission to see how an asteroid on a collision course with Earth could be deflected. ESA's plans include creating transportation and habitation modules for the Moon's space station, the Lunar Gateway; and further afield, it will support NASA's Mars Sample Return mission.

www.esa.int

Radar images southern aurora

Astronomers have recently published the first radar observations of the Southern Hemisphere's ionosphere.

The ionosphere lies between 75km to 1,000km in altitude, where radiation from the Sun blasts electrons from the molecules in Earth's atmosphere. These charged particles interact with Earth's magnetic field to create the aurora.

Researchers from Japan's National Institute of Polar Research used a radar telescope in Antarctica, called PANSY (the Program of Antarctic Syowa Mesosphere-Stratosphere-Troposphere/Incoherent Scatter), to take a look at the particles within the ionosphere. They will now use these observations to examine differences between the Northern and Southern Hemispheres, building up a global picture of the ionosphere and the aurora.
http://nipr.ac.jp


Was Itokawa formed by a sub-catastrophic collision?

How contact binary asteroids take shape

Dramatic asteroid collisions could result in peanut-shaped space rocks

Asteroids represent the material left over from the formation of the planets – like crumbs scattered on the cosmic kitchen table – and so their compositions and shapes can offer important insights into the origin of the Solar System. But the asteroids we see today have also had to make it through billions of years of history since then, and all the collisions of varying intensities that that entails. Just like our own Moon, the surface of asteroids are pock-marked with craters within craters, and larger impacts can catastrophically break up these objects. All asteroids smaller than about 50km in diameter are the result of fragmentation of a larger parent body. But even smaller-scale, sub-catastrophic collisions can greatly alter the overall structure of an asteroid without breaking it up completely.

In this sense then, properties of asteroids – such as their shape, interior structure and spin rates – are largely determined by the last large impact they've been in, so they could offer a record of the collisional history of the Solar System.

One particular category of asteroids are the contact binaries, which look like two blobs stuck together – almost like a space peanut. The average impact velocity in the asteroid belt is around 18,000km/h, and so encounters that are gentle enough to simply merge the two colliding bodies are exceedingly rare. Contact binaries are pretty common within the asteroid population, so what is the most likely process for them to have formed?

Collision course

Martin Jutzi, at the University of Bern, Switzerland, has been exploring this by running computer simulations of colliding space rocks. He calculated how impacting bodies deform, fragment and then gravitationally re-coalesce after collisions, treating asteroids as 'rubble piles', as this is the internal structure that most asteroids are thought to have. The asteroids varied in size from a few hundred metres to a few kilometres across.

He found that many of these sub-catastrophic impacts lead to a splitting of the rotating, elongated target asteroid into two components. But these remain gravitationally bound to each other and re-merge within a day or two to form a contact binary. A lot of the dusty material ejected off in the original collision also falls back and re-accretes onto the newly formed binary. This ejecta doesn't uniformly re-coat the binary, however, but creates craggy, rough regions mixed with much smoother patches of the original surface.

"The properties of asteroids are determined by their last impact, so they could offer a record of the Solar System's collisional history"

The resultant two-lobed objects created by Jutzi's simulated collisions bear a striking similarity to known contact binary asteroids. For example, the near-Earth asteroid Itokawa, which was studied up close by JAXA's Hayabusa space probe in 2005, is also characterised by interspersed regions of rough and smooth terrain. Considering the probabilities of collisions with impactors at different speeds and sizes, Jutzi concludes that such sub-catastrophic collisions are by far the most likely cause behind contact binary asteroids like Itokawa.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *The shape and structure of small asteroids as a result of sub-catastrophic collisions* by Martin Jutzi. **Read it online at https://arxiv.org/abs/1910.12689**

JAXA, ESO/VISION SURVEY

Where do baby stars come from?

The galactic environment could affect how infant stars grow

Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night*

Star formation is one of my favourite mysteries. It's to do with the fact that while we can describe what happens in just a few phrases – cold gas and dust collapses under its own gravity, until the density is high enough to sustain nuclear fusion – any attempt to add detail produces confusion and a seemingly never-ending list of questions. Wrestling with this classical astronomical problem are the authors of this month's paper, led by Heidelberg University's Mélanie Chevance.

Part of the problem is that the events that set a protostar's course take place deep within giant molecular clouds (GMCs), regions of cooling gas which are denser than their surroundings. A nearby example is Orion A, which includes the Orion Nebula and many of the clusters and nebulae south of Orion's Belt. We know, or at least suspect, that the processes that happen in GMCs are affected by the galactic environment; whether there are other young stars nearby, whether a supernova recently exploded in the vicinity, whether one is in a spiral arm or not. All of these things and more can affect whether the process of star formation gets started, or whether once started any particular collapsing cloud will indeed produce a star. But we have only really studied such clouds in the Milky Way and in a handful of nearby galaxies.

Clouding the issue

As a result, we know little about GMCs. We don't even know how long they live. Some think that an individual molecular cloud might persist for a hundred million years or so, forming multiple clutches of stars, while other astronomers suggest that a cloud exists for a mere (cosmic) blink of an eye, evaporating after no more than 10 million years. By looking at the properties of clouds in nine local star-forming galaxies using ALMA – the interferometer in the Atacama desert that's sensitive to sub-mm, or microwave, radiation – Chevance and colleagues hope to settle this debate.

> ***"Part of the problem is that the events that set a protostar's course take place deep within giant molecular clouds"***

ALMA provides maps of carbon monoxide, a key molecule found in the kind of denser gas seen in GMCs, and the team use observations of emission from hydrogen to trace where stars are actually forming. The ratio of the two (and a bit of complex maths and thought) gives an indication of how quickly stars are forming in each galaxy. The team's first finding is that the amount of gas available doesn't dictate how much star formation there is – something other than the presence of sufficient fuel must be significant. And in each galaxy though there is some variation, GMCs seem to come and go relatively quickly, lasting only tens of millions of years.

The overall picture is of a complex set of circumstances leading to the formation of any particular star. Even small disruptions to the environment, for example from the wind of a nearby young star, might be enough to disrupt star formation, or alternatively to destroy a GMC completely. The message is pretty clear. Understanding star formation requires getting into the detail and these observations are only the start.

Star factory: the Orion A molecular cloud, as captured by the VISTA infrared telescope, contains many young stars

Chris Lintott was reading... *The lifecycle of molecular clouds in nearby star-forming disc galaxies* by Mélanie Chevance. **Read it online at https://arxiv.org/abs/1911.03479**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

▲ Under the clouds: will Juno discover whether Jupiter has a solid core?

December's *Sky at Night* episode reviewed the year's top stories, including an update on NASA's Juno mission. Planetary scientist **Dr Caitriona Jackman** reveals the spacecraft's latest findings

On 4 July 2016 the Juno spacecraft arrived at Jupiter. It was the fastest human-made object in history (though it has now been overtaken by the Parker Solar Probe), and the first solar-powered spacecraft to operate so far from the Sun. Juno is an exceptional mission, with four headline science goals to study the origin, interior, atmosphere and magnetosphere of Jupiter in unprecedented detail.

The ambitious scientific aims can only be realised through a daredevil orbit, which takes Juno over the poles of the planet, the first mission to do so. At closest approach to Jupiter the spacecraft is a mere few-thousand kilometres from the cloud tops. But Jupiter is inhospitable and will not give up its secrets easily. All of this orbital planning has to be conducted within the constraints of its harsh environment: the planet's strong magnetic field traps charged particles into intense radiation belts, and in order to protect against this, Juno's most sensitive electronics are housed in a titanium vault at the spacecraft's heart.

Juno is executing a series of 53-day orbits, which are wrapping the planet in an orbital 'web' – ensuring full coverage of all latitudes and longitudes – so that its magnetic field and gravity can be fully mapped.

Some of Jupiter's most iconic visual features are also linked to our biggest unknowns: what allows storms like the Great Red Spot to last for hundreds of years? What are the constituents of the atmosphere that give the characteristic colours in the clouds?

In addition to Juno's key science payload there is JunoCam, a citizen science instrument that provides visible colour images of the cloud tops. These images show that the Great Red Spot is shrinking, and also reveal the complex structure of the polar regions, with multiple cyclonic storms, some 2,000km wide. The dramatic swirls of cloud in Jupiter's atmosphere have been shown to extend up to 3,000km deep and it is thought that some of the colour in the clouds may

Dr Caitriona Jackman is an associate professor of space physics at the University of Southampton

come from plumes of sulphur or phosphorus-containing gases rising from the warmer interior.

And as for Jupiter's interior? We don't know what's inside Jupiter and Juno's remote sensing instruments are helping us to answer the long-standing question of whether Jupiter has a solid core, and if so, how big it is. This question can help to frame Jupiter's place in the story of Solar System formation. Gravity measurements from Juno indicate that beneath the differentially rotating clouds, Jupiter rotates nearly as a rigid body, but the composition is as yet unknown.

Juno measurements continue to amaze scientists with their unpredictability. Its magnetometer has reported the first evidence of a time-varying planetary magnetic field beyond Earth. Much of this variation is thought be to linked to an intense magnetic anomaly called the Great Blue Spot, near the equator. It is possible that Jupiter's strong atmospheric winds in this region distort the magnetic fields in dramatic ways.

Right now, Juno and its subsystems are all working well, sending back a wealth of complex data for scientists to pour over, as well as raw JunoCam images for the public to experiment with. The mission, as planned, will orbit Jupiter until 2021 and we look forward to unlocking many of the giant planet's mysteries.

Looking back: The Sky at Night

5 January 1968

On 5 January 1968's episode of *The Sky at Night*, Patrick Moore joined up with two other amateur astronomers whose enthusiasm for their hobby had inspired them to build their own home observatories. The show took a look at the different kinds of observatories on offer at the time, hoping to inspire more people to create their own.

One of the observatories the show looked at was Patrick's own, which he had just transferred to Northern Ireland where he was serving as director of the Armagh Planetarium. However, he would only remain in the region a few months more, as political unrest prompted him to return to England. He moved to Selsey in Chichester, where he and his astronomy equipment would remain.

After Patrick's death, there were plans to turn his observatory into a historical site. Unfortunately, the lack of accessibility made the plan unfeasible. It was propsed to build a memorial observatory on a nearby field, but these plans were also dropped after being deemed too expensive, and meeting with local opposition.

A beginner's guide

The team reveals how to enjoy the night sky wherever you are. Pete Lawrence joins novice stargazers to discuss the best way to introduce newcomers. Chris Lintott marvels at the Moon through binoculars from a roof in Oxford. Maggie Aderin-Pocock goes back to her childhood telescope-making class to talk essentials. Curious about the night sky, or want to make the most of your new scope? This is the programme for you.

BBC Four, **12 January,** 10pm (first repeat BBC Four, **16 January,** 7.30pm)
Check www.bbc.co.uk/skyatnight for subsequent repeat times

▲ Watch this month's episode for advice about how to get started in stargazing

Emails – Letters – Tweets – Facebook – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize
four Philip's books

PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2020 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Night glow

After reading Will Gater's piece ('Chasing the Zodiacal Light', October), I was keen to get out and see if I could capture this mystical glow for myself. I knew there would be a good chance to spot it from Abersoch Beach in north Wales because the sky to the east is dark, looking over sparsely populated west Wales. I was lucky to capture the amazing glow of the Zodiacal Light around two hours before sunrise, spanning right through the constellation of Leo. I chose to photograph it over some beach huts, using the roofs of the huts to lead into the base of the glow on the horizon.

Stephen Cheatley, via email

Stephen catches the Zodiacal Light rising above beach huts

Tweets

John-GM7PBB
@GM7PBB • Nov 22
Cracking clear night now the clouds have parted #ness #isleoflewis #hebrides just waiting for the street lights to go off, pain :-) few #Meteors around tonight in the weak #Aurora over the #Atlantic @VirtualAstro @StormHour @chunder10 @TamithaSkov @skyatnightmag

Close encounter

"Country car parks are often frequented by people you'd rather not be involved with", says Robin Scagell (Field of View, December). That can work both ways. Our U3A Astronomy Group often stargazes away from any street lighting on ex-MoD land by a sea wall on the Essex coast. During a recent sky watching session a pair of headlights came along the track towards us. As the car's headlights came closer they picked up the sight of a dozen old-age pensioners with binoculars looking at them. The car ground to a halt, rapidly reversed and shot away. We thought it was probably a young couple, their evening ruined. We all felt quite sorry for them!

Barry Linton, Thorpe Bay, Essex

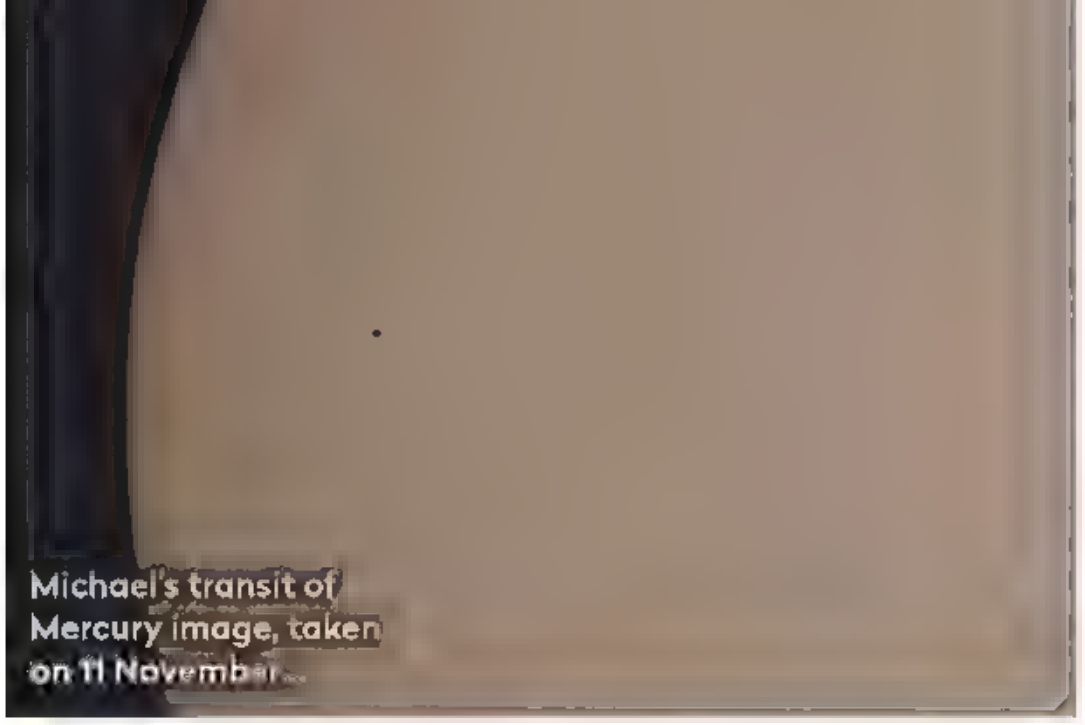
Blame the weather

Being an amateur astronomer in Britain is the most frustrating hobby that there can be. In preparation for the transit of Mercury I checked the weather forecast and it predicted sunny spells over me. Lots of patches of blue sky were visible as I set up my 200mm Newtonian telescope and solar filter at 11.30am. At 12.30pm I went out to watch the transit, and from then on there was a virtually constant band of black cloud obscuring the Sun. Above and behind me was lots of blue sky, but not where the Sun was. I packed up my kit at 3pm. In two and a half hours I saw Mercury for about 15 minutes. If Galileo had been British we would still think that the world was flat!

Chris Webster, Surrey

Mercury in motion

The transit of Mercury on 11 November was the first I've observed and involved the first proper astrophotos I've ever taken. I'm very happy with the results, although I had to peel myself away from the eyepiece to take the photos. What a



Michael's transit of Mercury image, taken on 11 November...

...and his impressive setup in Milton Keynes

fascinating thing to witness! The image (above, top) was taken at 1.25pm in Milton Keynes, with an Olympus E-PL7 at prime focus on a Sky-Watcher 200PDS and HEQ-5 mount, with a home-made Baader AstroSolar film filter (setup pictured above). I used single 1/800" exposures at ISO 100 with no further processing.

Michael Bate, Milton Keynes

Ditch plastic

Once again I have spent an enjoyable evening reading the December 2019 issue of the magazine. In particular I noted Derek Smith's letter, which highlighted the impact on the environment of travel by astronomers. Another impact is your magazine's packaging: as a subscriber, my copy is delivered in a plastic bag. *Sky at Night Magazine* is now in the ▸

ON FACEBOOK

WE ASKED: What is your New Year's resolution for 2020?

Martin Crowly To actually do some observations.

Michael Bate To capture my first clear deep-sky astrophoto which may not seem a lot to most, but given how proud I am of my blurry images I'll be 'over the moon' if I get a clear one!

Graeme Rebel Healey To be able to get out on at least 90 per cent of clear nights... if there ever are any again.

Steve Bowden To get a lot closer to full remoting of my observatory then begin writing some imaging workshops to promote the hobby further. I'm still working on designing a cloud Hoover and struggling. North Yorks can be tough at times.

Dave Archer Barclay To stop acting like a mad man when I point and swear at the clouds, whenever I go out with my telescope. My wife says the men with the white coats are going to take me away.

Vicki Pink To make the most of clear nights on the rare occasion, when we do actually get them!

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

My Celestron NexStar 6SE has fungus. Is there anything I can do to save my telescope?

SHIVAM UPADHYAY

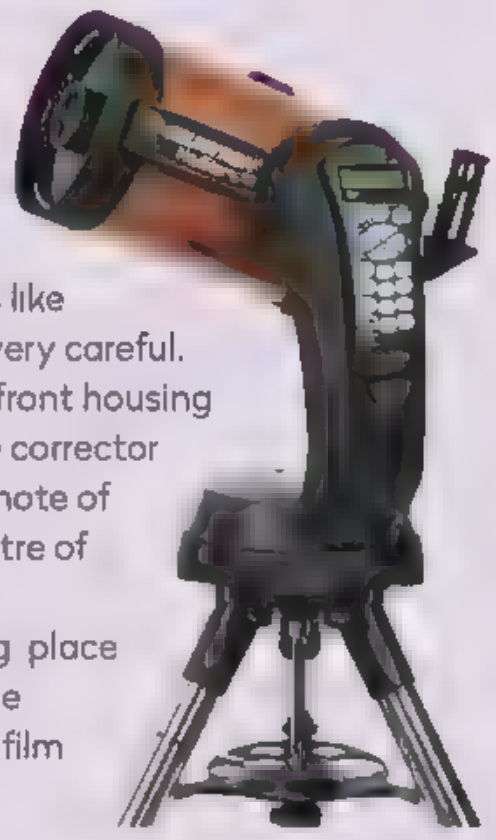
Fungal growth is sometimes found on the inside of the corrector plate and the safest advice is to have the telescope cleaned and serviced by the importer. However, non-Edge HD optics like yours can be cleaned by you if you are very careful.

Unscrew the retaining ring inside the front housing and accurately mark the position of the corrector plate relative to the housing, making a note of any offset of the corrector from the centre of the housing.

Remove the secondary mirror housing place it in a dust-free plastic box and place the optical tube somewhere safe with cling film over the front.

Soak the corrector plate in tepid water with a few drops of mild detergent for half an hour, then clean the corrector's surface very gently with a small piece of surgical grade cotton wool and a 1:1 mixture of isopropyl alcohol and distilled water to carefully remove the fungus.

Rinse with large amounts of distilled water, dry naturally then re-assemble and collimate.



▲ You could clean a scope such as a NexStar 6SE yourself, if you know how

Steve's top tip

What is a 'fast' telescope?

The expression 'fast' has its roots in photography. To explain it, imagine two identical cameras fitted with lenses of the same focal length, but one lens has a narrower aperture than the other. The camera with the wider aperture lens needs shorter exposures to capture the same amount of light, so the lens is 'faster'. The same is true for telescopes.

This 'speed' attribute is called focal ratio, and is determined by dividing the telescope's focal length by its aperture. For example, a scope with a 1,000mm focal length and 200mm aperture has a focal ratio of 5, normally written as f/5.

Telescopes with focal ratios below f/7 are generally known as fast, while those above f/9 are slow.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

BBC Sky at Night Magazine is published by Immediate Media Company Bristol Limited under licence from BBC Studios, which helps fund new BBC programmes.

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SUBSCRIPTION RATES
Annual subscription rates (inc. P&P). UK cheque/credit card £62.40; Europe & Eire Airmail £75; rest of world airmail £85. To order, call 03330 162119 (UK); overseas +44 (0)1604 973727

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Audit Bureau of Circulations
19,202 (combined; Jan–Dec 2018)

ISSN 1745-9869

Tweets

James Billings
@jowlymonster • Nov 19
I ventured out last night to shoot star trails over @Ely_Cathedral – I think it was about 2 degrees, so rather chilly. There's about 40 minutes worth of data in this image. @visitely @SpottedInEly @ChrisPage90 @ThePhotoHour @skyatnightmag

► minority of titles that aren't delivered in compostable bags. What are your plans to switch to eco-friendly packaging and when? It must surely be one of the magazine's New Year resolutions.
Tim Severn Hyde, via email

A timely message Tim. This issue is the first to be sent to subscribers in our new packaging: a 100 per cent recyclable, sustainably sourced paper envelope. – *Ed.*

Was Galileo a hero?

In his article ('Astronomers, your planet needs you!', November) Darryl Quantz uses the Galileo Affair to highlight how astronomers have championed scientific findings at personal risk. He appears to have shot himself in the foot by citing this example. In spite of the overwhelming evidence to the contrary – that is the copious notes taken during Galileo's trial and his own writings – Galileo is portrayed as a hero of the scientific method over the backward beliefs of the time, especially those of the Church. The truth is that Galileo did not prove the heliocentric nature of our Solar System or that Earth spun on its axis. Such proofs were not provided until much later with the discovery of stellar aberration and Foucault's pendulum. In addition to this lack of proof, Galileo had insulted his sponsor the Pope, and insisted the Bible be re-written. This all happened within the context of a Catholic Church battered and bruised by the events of the Reformation, trying to protect scripture. The events surrounding Galileo's trial are more complex than the article states and any serious historian of science appreciates that the Catholic Church was defending the scientific method.
Ian Maxfield, via email

SOCIETY IN FOCUS

The Beavers and Cubs of 1st Iver Heath Scout Group in South Buckinghamshire have been very busy in recent weeks learning about the Solar System and various space missions.

The Beavers (aged 6 to 8) gained their Space badge by learning about the planets, which they did by playing the 'fruit game', where they had to arrange different-sized fruits to match the order of the planets; as well as the 'toilet roll game', where sheets of toilet roll were used to indicate the huge distances between the planets. They also learnt about space missions by watching videos of the Mars Curiosity Rover and the James Webb Space Telescope. There was even an impromptu space quiz for the younger children organised by one of the Cubs.

On their first of two evenings to gain their Astronomer badge, the Cubs (aged 8 to 10) made and painted models of the Solar System using polystyrene balls and kebab sticks. Many of the children took their amazing models in to school the next day to 'show and tell' sessions and received house points. To complete their badge, next the Cubs will do a Moon and stargazing evening, when they'll have the opportunity to view the night sky through telescopes, binoculars and using apps, to learn about features on the Moon and the constellations they can see at this time of year.
Kerry Williams, parent, Iver Heath Scout Group
► **iverheathscoutgroup@gmail.com**

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WHAT'S ON

Star stories

Abriachan Forest, Inverness, 10 January, 7pm

There's fun in the forest with Star Stories, a family-friendly evening of stargazing and campfire storytelling. This is an eclipse special, with an opportunity to observe a live penumbral eclipse of the Moon. Entry costs £5 for adults and is free for children. **bit.ly/starstoriesinverness**

Stargazing at Hall Place

Bourne Road, Bexley, 7 January, 7pm

An evening looking at the stars in the company of Crayford Manor House Astronomical Society, Dartford. The event includes talks, quizzes, a comet-making demonstration and a variety of scopes to observe with (skies permitting). Booking is essential: it's £10 for adults and £8 for under 16s. **bit.ly/stargazing2020**

Winter stargazing

Cragside House, Morpeth, 18 January, 6pm

Join the team at Cragside House for a colourful talk on star clusters, galaxies and the swirling clouds where stars are born. Handle space rocks billions of years old and take a tour of the constellations with telescopes. Entry includes soup and a hot drink: adults £15, children 6 and over £7.50. **www.nationaltrust.org.uk/events**

Beginners' dark-sky tour

Grizedale Forest Visitor Centre, Ambleside, 24 January, 7.30pm

Robert Ince is your guide for this beginners' tour of the dark skies above Grizedale Forest. Powerful scopes and binoculars are provided. There's a talk about protecting dark skies. Entry is £15 adults, £7.50 children. **bit.ly/grizedale**

PICK OF THE MONTH

▲ A flare for science: enjoy the astronomical delights at Swansea's National Waterfront Museum

Stargazing on Swansea's Waterfront

National Waterfront Museum, Oystermouth Rd, Swansea, 18 January, 12–4pm

Swansea's modern National Waterfront Museum, slap bang on the edge of the city's marina, plays host to a free afternoon of astronomy fun this month with a full programme of activities designed to inspire all ages about all things space-related.

Among the highlights is 'Astronomical', a science show that leads visitors across space to visit the planets and moons before venturing out to nebulae and black holes. Presented by Scott Marley from the Science Theatre, it promises the opportunity to ask a scientist all about space.

If you think you might have found a meteorite, bring it along to get it verified by geologists. There'll also be a meteorite display, along with replicas of Galileo and Newton's telescopes from the National Museum Wales collections. If you have your own scope queries or woes, there will be hands-on help available from members of South Wales astronomical societies.

Dark Sky Wales will also be raising awareness of light pollution. Entry is free although dome shows cost £3.50. **bit.ly/amazingastronomy**

Star tracker evening

Armagh Planetarium, 28 January, 7pm

Head to Armagh Observatory and Planetarium for an evening of star tracking, with a digital theatre show and observations of the night sky through a 12-inch scope. Entry is £8 adults, £5.75 children. **bit.ly/armaghobservatory**

Stargazing 2020

Rutherford Appleton Laboratory, Didcot, 31 January, 5:30pm

Be quick to bag a ticket for this packed evening of space-related activities for the whole family, including rocket building comet making, talks and stargazing. **bit.ly/rutherfordappleton**

HIGHLANDASTROTOURS, NATIONAL WATERFRONT MUSEUM/SWANSEA

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Image of IC59 - 63, captured with the Horizon
courtesy of András Papp

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FIELD OF VIEW

I do like to stargaze beside the seaside

Brighton's night-time seafront may seem an unlikely place to go stargazing, but, as **Phil McAllister** explains, it can spark interest from a wide range of people

Phil McAllister is one of the leaders of Brighton Astro, and a keen practical astronomer

Brighton prides itself on being a little bit different: over the years it's evolved from a playground for philandering royals, to an incubator of alternative culture, and a home for people who never quite found their place in the everyday crowd. There's something for everyone in Brighton. Or so we thought.

In a town famous for night-time adventures it seemed strange there was no place for people who love to see the stars. And so, Brighton Astro was born, and like the city itself we pride ourselves on being a little bit different. Our goal was never to be the most expert group but to be a place where space enthusiasts can learn together. We wanted people who love to watch *The Sky at Night* and Brian Cox on TV, but might not know Orion from Uranus.

The stars belong to everyone, so our stargazing sessions needed to be accessible to the broadest range of people. And that meant being in a place that everybody knows and can get to easily. So that's why you'll find us stargazing from a beach hut on the seafront.

Now, Brighton seafront is not a dark place. It's full of colour – literally and figuratively, and with the South Downs National Park – a designated Dark Sky Reserve – a few kilometres away it may seem an odd place to set up telescopes. But we want to bring the stars to the public as much as our members, and it seems, the public loves stargazing as much as we do.

From hen parties, to homeless people, and teenagers to tourists, people who have never thought to look up have stopped by to get up close and personal with the night sky. For us, there's nothing more satisfying than hearing someone gasp in astonishment at their first glimpse of the craters on the Moon and the realisation that it's not just a disc in the sky.

One of our proudest moments was inviting a sneering group of teenage boys to take a closer look at the bright star they could see in the distance, and the string of amazed expletives they uttered when they realised it wasn't just a star, but majestic Saturn and its rings suspended in the sky.

Of course, popularity comes with its pitfalls, and the buzzing crowd once drew so much interest from passers-by that we had a police car slowly patrolling past, looking perplexed that instead of a rave or riot a group of happy stargazers, excited kids and the odd dog trying to cock a leg against a tripod blinked back at them. If we ever get the helicopter out we'll know we've really made it.

Stargazing in places with heavy footfall is a wonderful experience. You may not see deep-sky objects, but you become the gateway to the stars for all kinds of people who might never have known just how beautiful our Universe is.

ALEX GREEN/FOLO ART

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BBC Sky at Night MAGAZINE

20 SIGHTS TO SEE IN 2020

As we begin a new decade, **Mary McIntyre** takes a look at some of the best astronomical views to be seen in its first year

Mary McIntyre is an astronomer and dedicated astro imager based in Oxfordshire

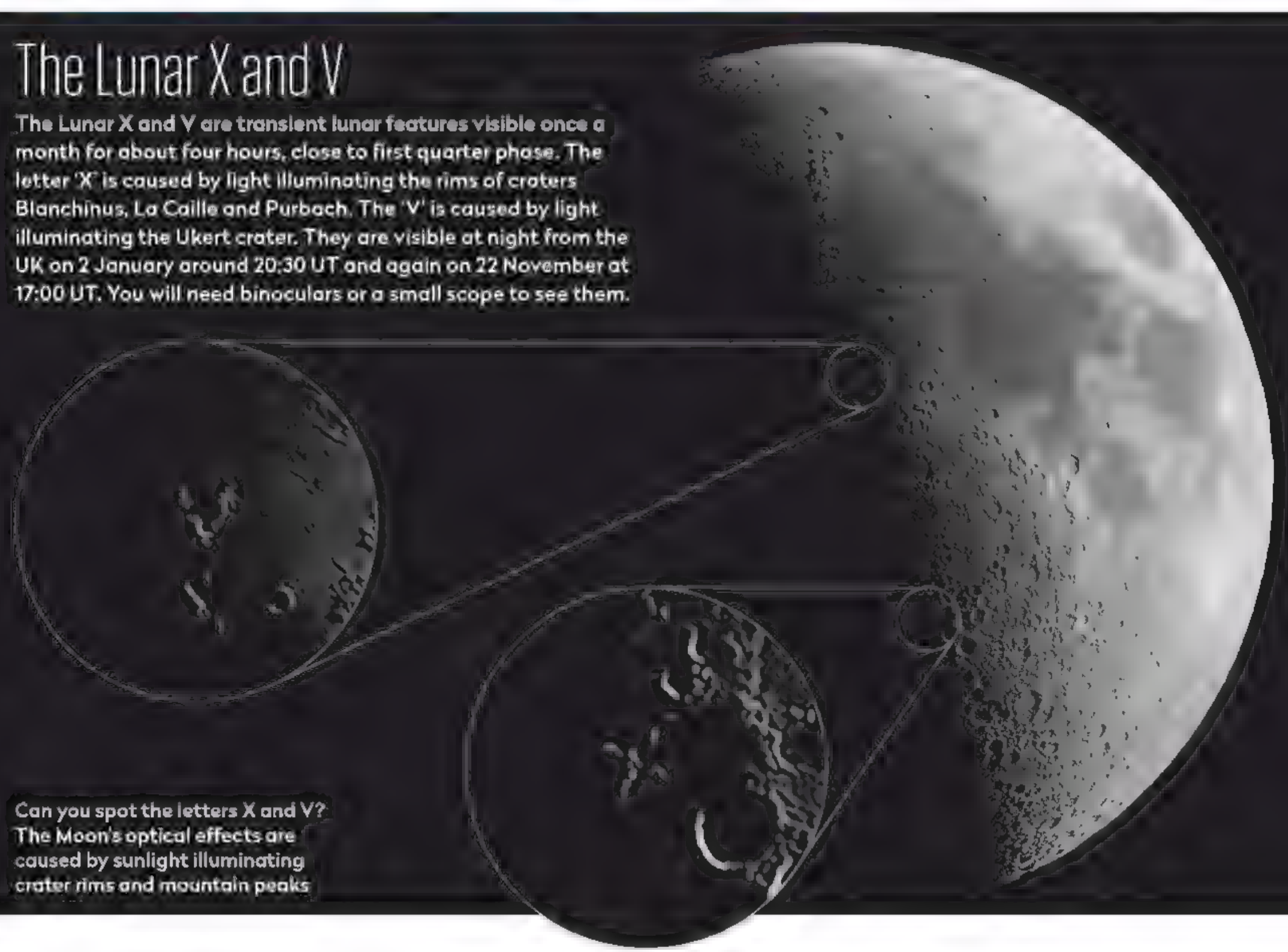
PETE LAWRENCE. MICHAEL BRETTE/ STEFAN HEUTZ/ WOLFGAN RIES/ CCDGUIDE.COM, YOKO KEN CHAN/ISTOCK/GETTY IMAGES

The coming year is shaping up to be a great one for astronomy with some interesting rare events. The night sky is packed with gems and many can be observed with the naked eye. But you can also use binoculars to help you learn your way around the sky and investigate some objects that wouldn't otherwise be visible, or probe deeper with a telescope and discover some beautiful objects, such as clusters, galaxies, nebulae and planets.

Here we list some of the best sights of 2020 with something for every ability level and there's even a few great photo opportunities. Why not see how many of these objects you can observe?

The Lunar X and V

The Lunar X and V are transient lunar features visible once a month for about four hours, close to first quarter phase. The letter 'X' is caused by light illuminating the rims of craters Blanchinus, La Caille and Purbach. The 'V' is caused by light illuminating the Ukert crater. They are visible at night from the UK on 2 January around 20:30 UT and again on 22 November at 17:00 UT. You will need binoculars or a small scope to see them.



Can you spot the letters X and V? The Moon's optical effects are caused by sunlight illuminating crater rims and mountain peaks

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▽ Constellation of Auriga

Auriga, the Charioteer is visible all year round but is better placed for observing from January to April and August to December. It's worth investigating with binoculars as it is packed with open clusters, including M36, M37 and M38.

M37, the largest open cluster in Auriga

Asteroid 4 Vesta

Vesta reached opposition last November, but it is still well placed for observation through binoculars during January and February. In January, mag. +7.5 Vesta is visible in the constellation of Cetus to the south, from sunset until it sets at around 02:30 UT. By the end of February, Vesta will fade to mag. +8.0, setting around midnight. If you track the asteroid over several days, you'll see its movement relative to the background stars.

Constellation of Orion ▷

Orion, the Hunter is a highlight of winter. During January and February it dominates the southern sky, making it easy to spot. Look for the colour difference between the red giant star Betelgeuse on the top left and the blue supergiant star Rigel on the bottom right. If you observe Orion's Sword with binoculars, you will see that the middle "star" is actually M42, the Great Orion Nebula; a great astrophotography target for beginners. We lose Orion in late March but he returns in October. ▸

The Hunter's conquest: Orion dominates the night sky in winter

The Pleiades, M45

This beautiful star cluster is well placed for observation from January to March, and from October to December. It contains hot, young, blue stars less than 100 million years old. They are surrounded by a reflection nebula of gas and dust, and through binoculars the blue colour is really apparent, while long exposure photography can pull out the detail.

True blue: use binoculars to bring out the colour of the Pleiades

Venus appears to the right of a crescent Moon in March

◁ Venus

The dazzling planet Venus puts on a great show during the first few months of 2020. In January it will be visible for about two hours after dusk. From January to April it climbs higher in the southwestern sky and by April it sets around half past midnight. If you look at Venus through binoculars or a telescope over these months, you'll see its phase change from gibbous in January to crescent in April. Throughout this time its magnitude will change from mag. –4.0 to mag. –4.5. During this apparition several conjunctions will present excellent photo opportunities. On 27 February and 28 March, the waxing crescent Moon will be to the lower left of Venus, with the Pleiades above them in March. From 2 to 4 April, Venus will actually lie within the stars of the Pleiades, creating a rare and stunning spectacle.

Saturn, Mars and Jupiter in conjunction

During late March and early April, Saturn, Mars and Jupiter put on a show in the dawn sky. On 20 and 21 March, the three planets rise at around 4am in the southeast. Mag. –2.0 Jupiter will lie just 0.75° from mag. +1.0 Mars with mag. +0.7 Saturn to the left. You should be able to see both Mars and Jupiter in a 40-inch (1,000mm) scope. Over the subsequent days, Mars drifts closer to Saturn and on the mornings of 31 March and 1 April Mars and Saturn lie just 0.9° apart.

▽ Constellation of Hercules

Globular cluster M92 is a rewarding target

Hercules is well placed for observation from March to July. In March it rises in the east at around 22 00 UT and remains visible all night long but by July it will already be high in the sky after sunset. Hercules is home to two gorgeous globular clusters that are perfect for binocular or telescope observing. The larger of the pair, M13 lies about a third of the way down from the top right star and has a magnitude of +5.8. But don't forget to hunt down often overlooked M92. M92 is located to the upper left of the central square of stars, known as the Keystone, and at mag. +6.3, it too is an impressive globular cluster.

Full Moon, Spica and Arcturus in conjunction

The April full Moon occurs on 8 April, when the Moon is at its closest point to Earth, known as perigee. Perigee full Moons – also known as supermoons – can appear 14 per cent bigger and about 30 per cent brighter (but you won't be able to notice this with the naked eye). On 8 April the Moon rises at around 21:30 BST and remains visible all night long. The bright star to its right is Spica, the brightest star in the otherwise faint Virgo. The bright, orange-coloured star to the upper left of the Moon is the red giant star Arcturus.


M44 appears close to the Moon on 6 March

◁ The Beehive Cluster, M44

The Beehive is a beautiful open cluster located in Cancer, which makes a great target for binoculars and small telescopes. It is well placed in the southern sky from January to May. Because it is located near to the ecliptic, every month the Moon passes close to M44 during spring. The closest of these passes is on 6 March when the waxing gibbous Moon lies only about 1° away.


High profile: Noctilucent clouds are lit when the Sun is below the horizon

Noctilucent clouds (NLCs)

[illegible] observing time, is the appearance of noctilucent or night shining clouds. These clouds are made of tiny ice crystals so high in the atmosphere they're on the edge of space. They are seen low in the northwest 60-90 minutes after sunset, or in the northeast 60-90 minutes before sunrise. Because they are so high, they remain illuminated by the Sun and seem to glow.


Neighbourhood watch: M31 is the closest spiral galaxy to the Milky Way

◁ The Andromeda Galaxy, M31

Located 2.5 million lightyears away, the Andromeda Galaxy is the most distant object visible to the naked eye and is well placed for observation from August until December. At mag. +3.4, M31 is visible to the naked eye from a dark-sky site, appearing as a faint smudge. Through binoculars you will see an oval shape, but a telescope will reveal more detail. You can also use a small telescope to photograph this beauty, so it's a great beginner's target. Use the Square of Pegasus to help you locate M31 and see if you can spot the two satellite galaxies, M32 and M110. ▸

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This remarkable image of Mars at opposition in 2018 was taken by the 1m Chilescope and processed by Damian Peach

Mars

Mars will put on a great show this year. It returns to the southeastern dawn sky at the end of March, when it rises shortly before sunrise and will rise earlier each day throughout the summer, until reaching opposition on 13 October. During October, Mars will be visible all night long. Its apparent size and magnitude can vary enormously depending on where Earth and Mars are relative to each other in their orbits. During the 2020 closest approach, Mars will be 62 million km from Earth. At farthest approach, it will be 325 million km away; you can see why its appearance changes so much. Between March and October, the disc of Mars will increase from 6 arcseconds to 22.6 arcseconds and the magnitude will increase from mag. +1.5 to mag. –2.6. Although the apparent size of Mars isn't quite as large as it was during the 2018 apparition, it will be situated 31° higher, making it easier to observe.

The Milky Way ▷

July and August are the best months to view the Milky Way from the UK. You don't need binoculars or a telescope, but you will want to find a dark sky and a moonless night. While the band of the Milky Way sweeps across the whole sky, the portion that is close to the Galactic core is situated low in the south so you will need a clear southern horizon to see it. During the summer of 2020, Jupiter and Saturn are located to the left of the southern Milky Way and this will make a great photo opportunity.

Try and capture the Milky Way with Jupiter and Saturn

▽ Brocchi's Cluster

Brocchi's Cluster, also known as The Coathanger, is a quirky little open cluster nestled within the band of the Milky Way. It is not a true cluster as its stars aren't gravitationally bound to each other; it's just a line of sight effect. It is located half way between Vulpecula and Sagitta and is well placed from June until September. You'll need binoculars or a small telescope to spot it visually. Although small, it makes a great telescope photography target.

Brocchi's Cluster is well placed for summer observing

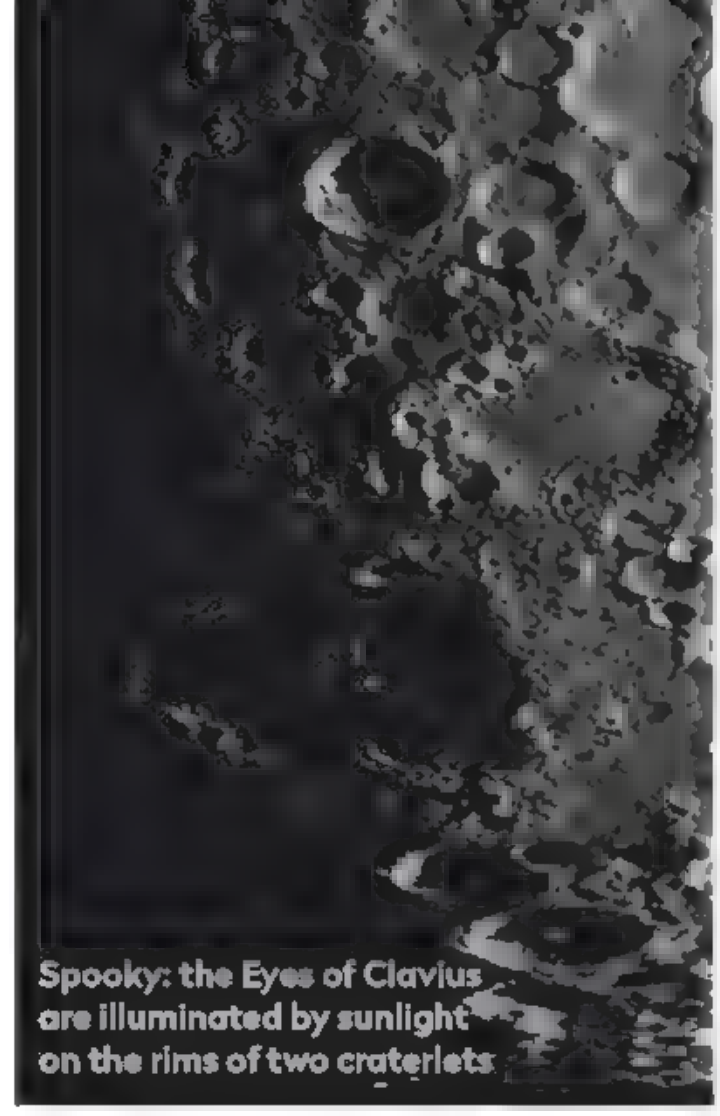
Albireo A & B

Albireo is the second brightest star of Cygnus, located at the end of the Swan's 'neck' at the opposite end of the constellation from its brightest star, Deneb. It is in fact a double star and is probably the most magnificent colour-contrasting double star in the Northern Hemisphere. When viewed through a telescope, the primary star, Albireo A, is a golden yellow colour. In stark contrast, Albireo B looks a much cooler blue colour. This double star is well placed for observing from June to September.

D PEACH/V SUC./CHILESCOPE TEAM MARY MCINTYRE X 2, KNICKOHR/ISTOCK/ GETTY IMAGES, STEVE MARSH, PETE LAWRENCE X 3

Moon, Jupiter and Saturn in conjunction

Jupiter and Saturn are located close together for most of 2020, but there are two occasions when the Moon joins them, making a lovely grouping. On 5 July, during a full Moon, the trio is located to the left of Sagittarius, and they rise in the southeast at about 23:15 BST, remaining visible until dawn. On 22 October a 41%-lit waxing crescent Moon joins Jupiter and Saturn They will become visible in the southern sky after sunset and set about 23.00 BST.



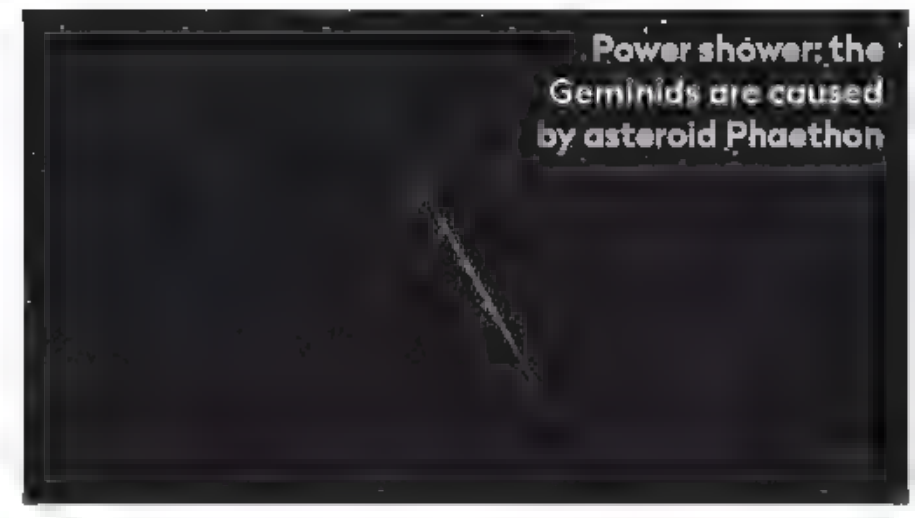
Spooky: the Eyes of Clavius are illuminated by sunlight on the rims of two craterlets

◁ The Eyes of Clavius

When the Moon is about 8.5 days past new the Sun rises over one of the largest lunar craters, Clavius While the crater floor is still in shadow the rims of two of its craterlets, Clavius C and Clavius D, become illuminated. These white circles shining out from the shadows give the spooky impression of two eyes staring out at you. The Eyes of Clavius are visible at 22:00 BST on 25 September. The Moon will be low in the south at this time, but you should be able to see the eyes using binoculars

Geminid meteor shower ▷

Almost all of the principal meteor showers in 2020 are affected by moonlight, but the Geminids is the one exception. This shower, caused by Earth passing through the debris stream left behind by the asteroid Phaethon is active from 4–17 December, peaking on the night of 13/14 December. This is a prolific shower with a Zenithal hourly rate of about 120 meteors per hour; this equates to a visual rate of approximately 30–50 meteors per hour. The radiant is well placed all night plus the peak coincides with a New Moon, making 2020 a promising year for winter meteors.

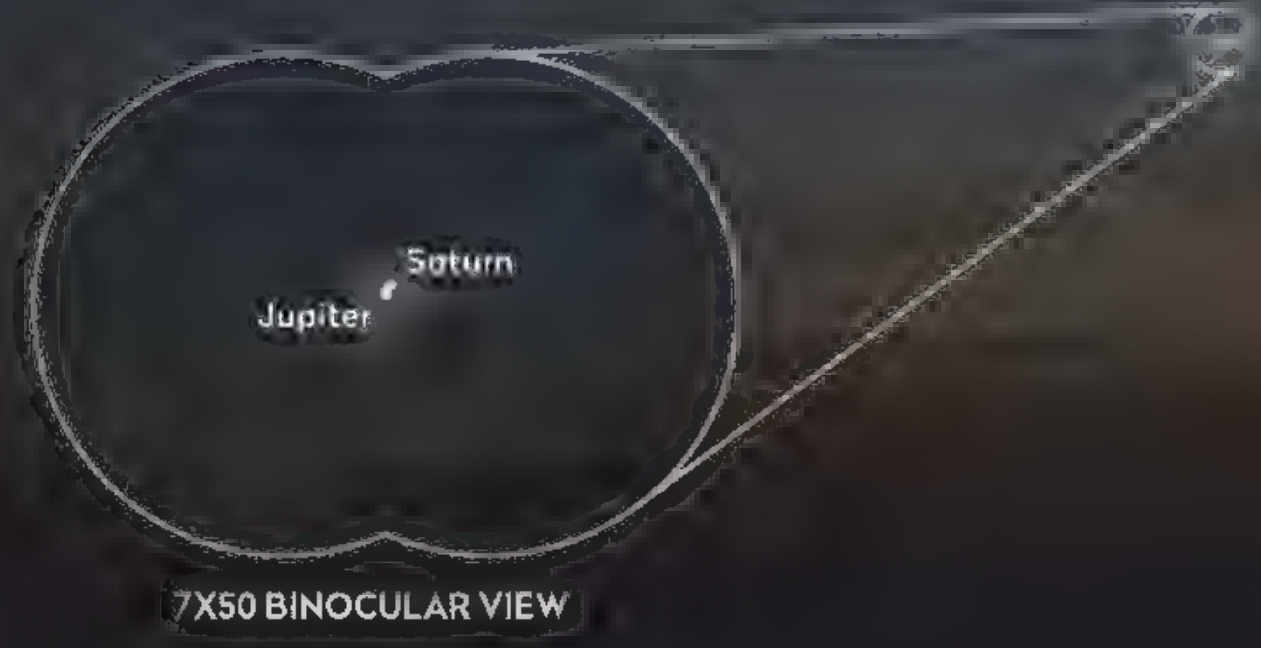


Power shower: the Geminids are caused by asteroid Phaethon

Saturn and Jupiter: 2020's great conjunction

Saturn and Jupiter spend much of 2020 close together, but during December they pass very close to each other in the sky. On the evening of the Winter Solstice on 21 December, the two planets will be separated by only 6 arcminutes, so they will look like one planet to the naked eye. They will both fit within the field of view of a moderate scope. It will be a huge treat to see Saturn's rings and Jupiter's cloud belts and Galilean moons in the same field of view. They become visible in the southwestern sky soon after sunset at about 17:00 UT. As they will be just 9° above the horizon you will need an unobstructed horizon. They will continue to sink lower until they set at around 18:15 UT. Don't miss this opportunity, as Saturn and Jupiter conjunctions are rare and the next one won't happen until 2040.

▲ Jupiter and Saturn will both be visible in the same field of view (as viewed south-up through a telescope)



At 17:30 UT on 21 December Jupiter and Saturn will be so close together they will appear as a single point of light in the sky

"It's time to get on with it": he may be 90, but Buzz Aldrin remains as passionate as ever about getting humankind back to space

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BUZZ ALDRIN: Still aiming high at 90

Buzz Aldrin, the second person to walk on the Moon, has led an extraordinary life. He talks to Rod Pyle about his passion for spaceflight as he celebrates his 90th birthday

When Buzz Aldrin talks to you, the topics always turn to spaceflight. And the discussion will not be primarily the reminisces of an ageing moonwalker as you might expect, but about the future of human spaceflight and the role of young people – from all nations – to achieve it.

You see, Buzz is a visionary, and vision is something that must be shared.

As his son Andy recently told me, "It's absolutely his life's work... he never stops thinking about it." Buzz's passion for spaceflight is boundless, and he's impatient as hell to see humanity get back out there. And as he turns 90 on 20 January 2020, he wants it to happen soon.

Buzz remembers clearly when his passion for flight evolved into one for exploring space. After graduating from the US Military Academy at West Point in 1951 he spent two years flying jets in the Korean war. Buzz then flew aerial patrol in Europe suporting NATO, and enrolled at the Massachusetts Institute of Technology (MIT) to study astronautics in 1959. It was while at MIT that he heard President John F Kennedy's challenge to send American astronauts to the Moon.

"The country was swept up in the space programme, and I wanted to be a part of it," Aldrin recalls when I spoke to him, "But NASA retained its requirement that astronauts have a diploma from a military test pilot school – not one of my credentials.

▲ Buzz cut: an early photo of Aldrin from his West Point Military Academy yearbook

"Since I knew that the Moon landing programme Kennedy had described would need astronauts with skills other than the ones they drummed into you at test pilot school, I opted for another 18 months of intensive work on a doctorate in astronautics, specialising in manned orbital rendezvous."

It took two applications to become a NASA astronaut but by 1963 he was accepted and was immediately assigned to work on orbital dynamics and rendezvous for the upcoming Gemini Program.

Preparing for space

Gemini started flying in 1965, and Buzz's Gemini 12 flight was the last of the missions. As with all the Gemini flights, there was a long list of objectives to be fulfilled, but perhaps the most critical was that of extravehicular activity (EVA), also known as spacewalking. Performing tasks during EVA was deemed critical for the Apollo Program, and one that had not yet been mastered despite many attempts on previous Gemini flights. Other astronauts who had attempted to perform tasks in zero gravity had become overheated and physically exhausted. Aldrin's mission was the last chance to get it right.

Buzz was determined to hit his marks. He spent hours training for his EVA; far more than NASA mandated. He repeatedly went up in the Zero-G simulator aircraft but was not convinced that the minute-long periods of freefall were enough to assure success. But NASA had started experimenting with ▸

▸ underwater training, and Aldrin, already an avid scuba diver, seized on this opportunity. He could be found day after day in a pool that NASA had rented from a high school, sealed in a Gemini pressure suit, clambering over the Gemini simulator in the deep end of the water.

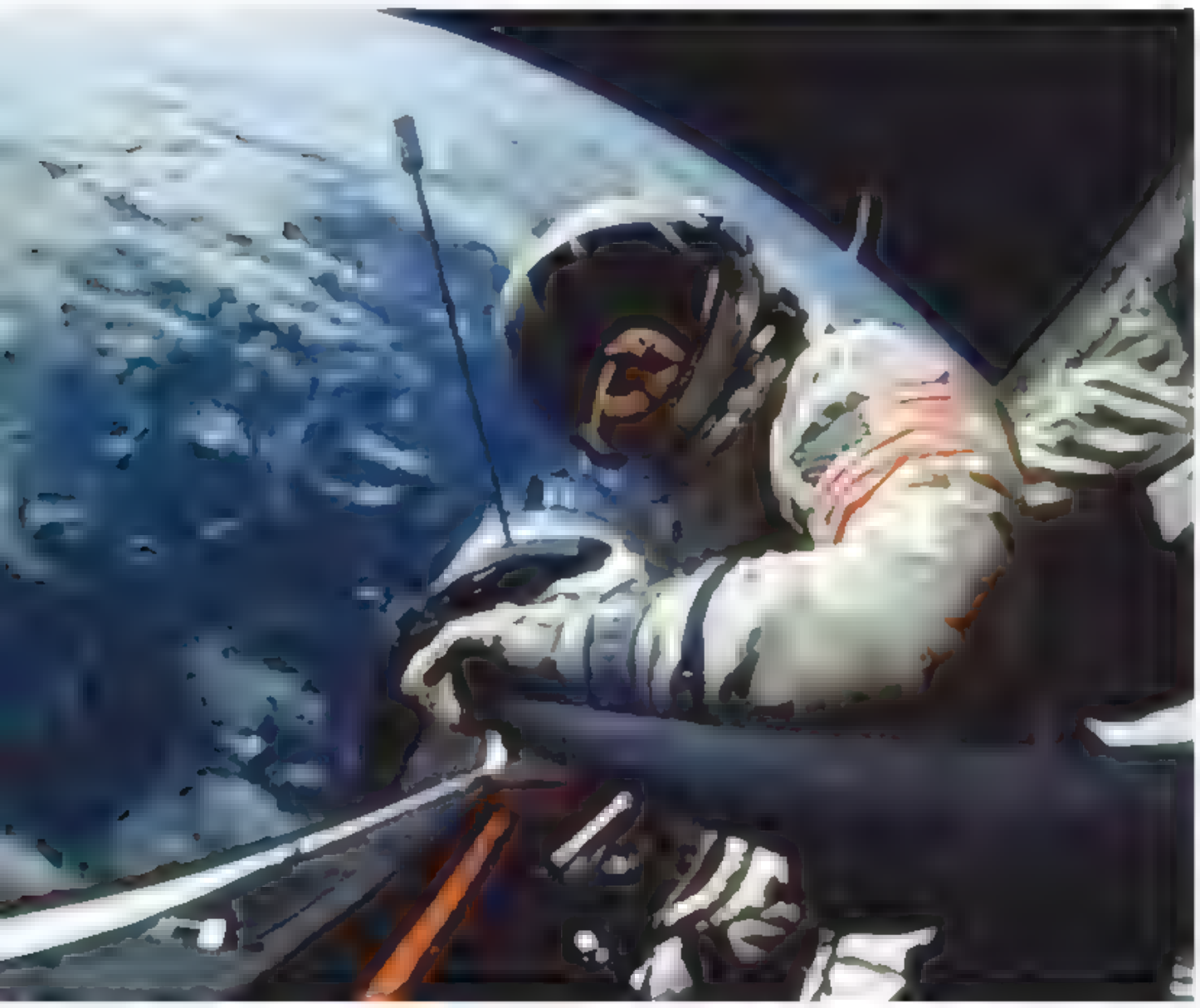
Then on 11 November 1966, it was time to strut his stuff on Gemini 12 alongside Jim Lovell. Buzz's first triumph came just hours after launch, when he had to manually guide the spacecraft to their docking target – an unmanned Agena rocket stage – when the Gemini's radar failed. He did so using paper charts, a sextant, and a slide rule – and burned less fuel in the effort than any previous flight.

Days later it was Buzz's turn to try to master EVA. The first spacewalk was a simple 'stand-up' affair, rising from his seat through the open hatch and taking photographs. For the second and far more challenging spacewalk the next day, he carefully made his way out to the Agena stage and placed an experiment there, before moving toward the rear of the Gemini capsule. He made it look easy. Once at the rear section of the spacecraft, he easily performed the tasks that had so vexed his predecessors – turning bolts and manipulating fixtures on a unit they called 'the busybox'. In just over two hours, Aldrin had completed the final major objective of the Gemini missions. As he later put it, "Project Gemini had finally triumphed. All of its objectives had now been met. We were ready to move on to Project Apollo and the conquest of the Moon."

NASA X 8, U.S FEDERAL GOVERNMENT

▲ **At the deep end: Buzz spent long periods submerged in a pool practising for his spacewalk...**

▼ **...which he went on to perform flawlessly during NASA's Gemini 12 mission**



In late 1968, Aldrin was assigned to the crew of Apollo 11 with Neil Armstrong and Mike Collins. Training started immediately and did not let up for the next six months.

Destination Moon

On 16 July 1969, every preparation that could be made for the first landing attempt was complete, and at 9:32am Eastern Daylight Time, they were off. A few days later, and after a harrowing landing during which the guidance computer locked-up multiple times the lunar module (LM) Eagle set down on the Sea of Tranquility. After a rest period, it was time to explore. They suited up and depressurized the cabin – but when they tried to open the hatch, it wouldn't budge. Despite having opened a valve to vent the LM's oxygen, there was still too much pressure inside the cabin.

"We didn't fly 240,000 miles [386 000km] to not explore the Moon," Aldrin later told me. "I reached down and grabbed the corner of the hatch and flexed it back – there was a hiss of escaping oxygen, and it swung open... You do want to be a little careful about not bending that door," he added with a chuckle.

Stepping onto the lunar surface about 20 minutes after Armstrong, Aldrin turned to see a sweeping view of the stark terrain. Aldrin said, almost dreamily "Magnificent desolation". That term, forever etched in our collective memories, remains the most poetic description of the lunar surface by any astronaut.

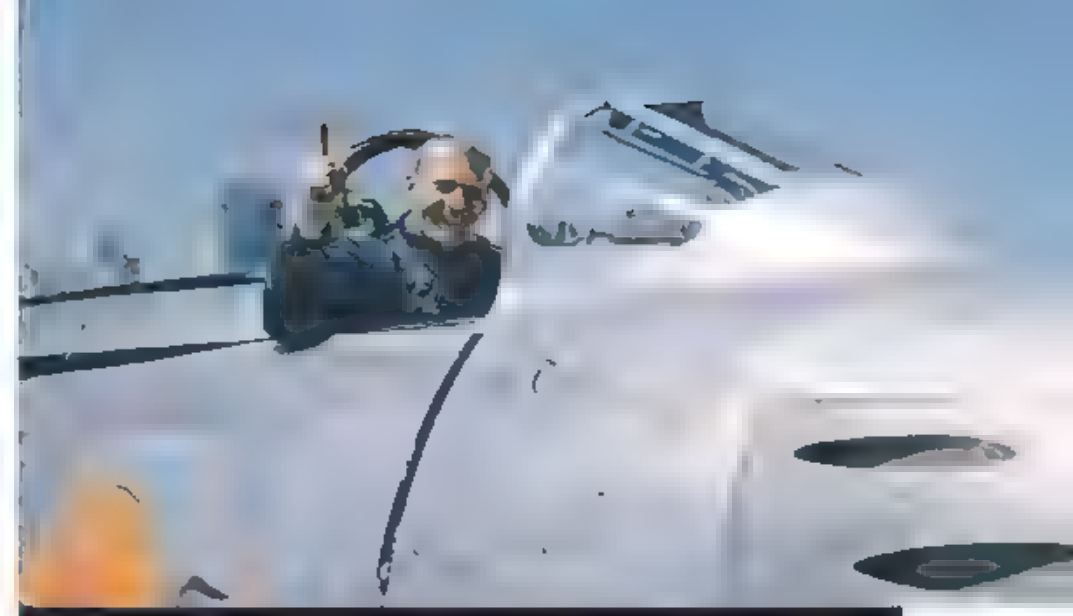
Just over two hours later, as they re-entered the LM, the astronauts noticed a small plastic tab on the floor of the cabin. When Armstrong had been manoeuvring his way out of the LM, his backpack had brushed a switch, snapping it off – it was the ascent engine arming breaker, the very switch they would need to throw to return to lunar orbit. As they rested, Mission

Control developed a time-consuming workaround, but as the astronauts prepared for lunar liftoff about 10 hours later, the ever-pragmatic Aldrin looked at the breaker – now just a plastic hole in a panel – pulled a pen out of his pocket, and jammed it inside the switch. Problem solved for less than the cost of a beer.

After splashdown, their ordeal was still not over – the trio would spend the next three weeks in quarantine. "It was a bit of a blessing," Aldrin would later say. "We had time to decompress."

At one point during their lockdown, Armstrong and Aldrin were watching recorded footage of the moonwalk. Aldrin smirked, and turned to Armstrong. He recalls saying, "Neil, you know what? We missed the whole thing!" ▸

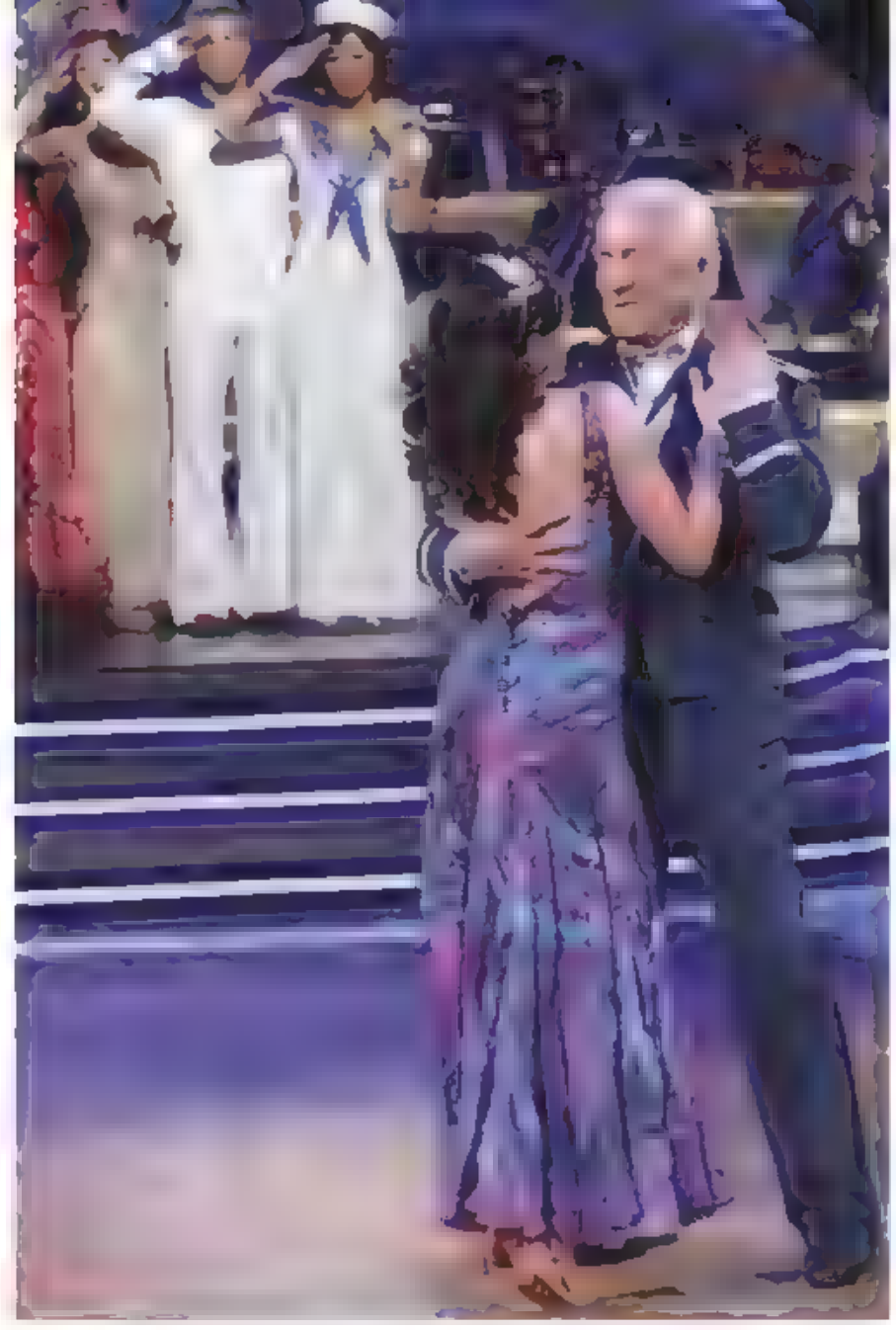
▲ Making history: after months of training and a three-day flight to the Moon, Aldrin set foot on the lunar surface and became the star of some of the most iconic images of the Apollo era



High flyer: a career takes off

Buzz Aldrin's flight career spans decades and orbits. Here are some of the high points

- During training at Bartow Air Base in Florida, Aldrin attempted a double-Immelmann (a complex aerobatic manoeuvre) and briefly blacked-out from g-forces. He recovered just in time to avoid crashing.
- Trained in single-seat jet fighters including the F-80 Shooting Star and F-86 Sabre at Nellis Air Force Base in Nevada.
- Flew 66 combat missions in Korea in the 16th Fighter-Interceptor Squadron, and shot down two enemy aircraft, 1952–53.
- Received two Distinguished Flying Crosses and three Air Medals.
- Flew the F-100 Super Sabre, armed with nuclear weapons, on patrol in Europe 1956–59.
- Gemini 12 launched on 11 November 1966 and returned on 15 November. First manual orbital rendezvous with an Agena docking target vehicle.
- Apollo 11 launched on 16 July 1969. Buzz Aldrin and Neil Armstrong land on the Moon on 20 July 1969.
- Flight time: 2,500 hours in aircraft (2,200 in jets); 3 days, 22 hours in the Gemini spacecraft; 8 days, 3 hours in Apollo spacecraft.



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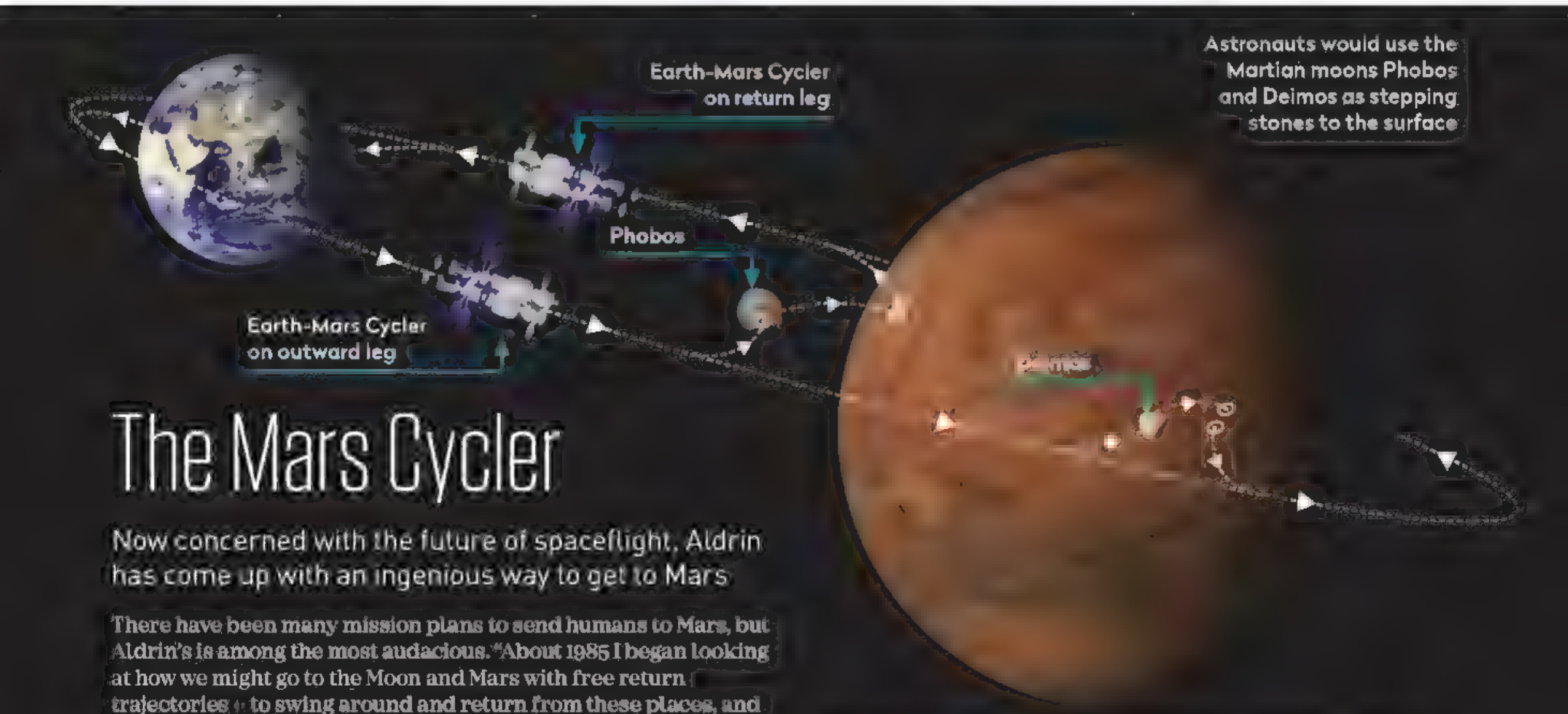
▲ **Creating a buzz: Aldrin engages a new generation of TV viewers on *Dancing with the Stars* in 2010**

▸ After a whirlwind world tour, the crew went their separate ways. Armstrong headed off into a university teaching career, and Collins to lead the National Air and Space Museum. But Aldrin was struggling with his future: how would he follow up such a magnificent experience? As he wrote in an autobiography called *Magnificent Desolation*, "I wanted to resume my duties, but there were no duties to resume," adding, "There was no goal, no sense of calling, no project worth pouring myself into." Not that there weren't plenty of offers – he spent time on the board of a major insurance company and began what would become a lifelong engagement with university students. But it was simply not enough. Nothing was enough.

In his books about his career, he spoke openly about facing what he now realised was chronic depression, and his struggles to cope, using alcohol as a crutch that ultimately became an addiction. This was an incredibly bold step – combat pilots and astronauts rarely discussed such things among themselves, and certainly never with the public. But Aldrin felt it was important for the world to know the pressures people such as himself worked under, and the ultimate costs that could accrue.

In the succeeding years he overcame these challenges, emerging as somewhat of media favourite with appearances on numerous TV shows including *Dancing with the Stars* (2010), *The Simpsons* (1994) and *The Big Bang Theory* (2012), as well as numerous documentaries. He became a staunch advocate of the human exploration of space, continuously pushing NASA to go farther, returning to their roots as leaders of human space exploration.

As part of this effort, in 1987, Aldrin joined the Board of Governors for the National Space Society



The Mars Cycler

Now concerned with the future of spaceflight, Aldrin has come up with an ingenious way to get to Mars

There have been many mission plans to send humans to Mars, but Aldrin's is among the most audacious. "About 1985 I began looking at how we might go to the Moon and Mars with free return trajectories – to swing around and return from these places, and this led to the cyclers," says Aldrin.

The Aldrin Mars Cycler is a large spacecraft that would orbit between Earth and Mars on a continuous, looping trajectory. Once in this orbit, no further propulsion is required – the Cycler provides, in effect, a permanent free ride between the two planets. At each end of the journey, crew members are shuttled between the Cycler and the nearest planet by a 'taxi' spacecraft.

The Mars Cycler itself would probably look something like a smaller, modified International Space Station, though some have even suggested that a small asteroid could also be used, with living facilities burrowed inside. Aldrin has recently repurposed his designs to include a Lunar Cycler that would maintain a permanent pathway between the Earth and the Moon.

► Mars in his sights: Buzz tries out a Microsoft HoloLens mixed reality headset at the Kennedy Space Center's Destination: Mars experience in 2018

(NSS), a preeminent pro-space organisation. "There are a lot of organisations that have been a joy for me to be with," he said, "but the NSS is one that is available to all," adding that a key purpose is to "exchange... ideas that stimulate".

Space is the place

Today, Aldrin continues to advocate for returning humans to the Moon and then onward to Mars. He remains a prominent voice for internationalism in space, pushing for greater collaboration with a number of nations, most notably China. He recently formed the Human Spaceflight Institute to continue the push and is working to form a global alliance for space exploration.

"Let NASA put this together along with the Europeans, Japan, Russia and China," he told me along with commercial entities. "I'm very interested in dealing with international groups. It's very crucial to not have a competition with China," he says. "We're better at problem solving as an international group of thinkers."

Now 90 years old, Buzz Aldrin remains a true force of nature. It often seems as if there are five brilliant minds competing for one mouth, and the ideas and plans come fast and furious, as he continues to work towards his final legacy: humanity's greatest adventure.

"50 years after Apollo, what can we actually do?" he recently said. He's not a fan of NASA's current plans. "We don't need a permanent orbital structure at the Moon," he says of the planned Lunar Gateway, which he thinks could be better employed as a transit vehicle between the Earth and the Moon. "If that's not a winner, I don't know what is," he says. But he then summed up the interactions between people like himself and NASA with a chuckle. "It's hard to mix fighter pilots with managers..."

That may be true, but after nearly a half-century of developing ideas to return humans to deep space his ideas seem to be increasingly relevant.

"It's time to get on with it," he concluded. "Now."

Rod Pyle is an author and journalist. He has written 15 space books and is editor-in-chief of *Ad Astra* magazine for the National Space Agency

◄ Force of nature: Aldrin is a keen author who passionately advocates for a global alliance to get humans into space and to settle on Mars

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Steve Tonki [illegible] of the best sights for [illegible]

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- This week of the eastern
- Can you locate the

Red light friendly

vision, this Sky Guide can be read using a red

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JANUARY HIGHLIGHTS

Your guide to the night sky this month

Thursday

2 The clair-obscur effects which gives us the lunar X and V occur this evening. Both can be seen on this evening's first quarter Moon at around 20.30 UT.

Tuesday

7 This evening the 89%-lit Moon sits inside the northern half of the Hyades open cluster, lying 2.3° north of the mag. +0.8 star Aldebaran (Alpha (α) Tauri).

◀ Saturday

4 The peak of the Quadrantid meteor shower occurs on the night of 3/4 January. A bright 57%-lit waxing gibbous Moon will spoil the early part of the display but sets at 01:10 UT, leaving the morning of the 4th perfect for Quadrantid viewing. See page 47.

Wednesday

8 This morning the bright 90%-lit waxing gibbous Moon will pass across the northern half of the open cluster NGC 1647 in Taurus.

◀ Sunday

12 The centre of the almost full Moon lies 43 arcminutes north of the centre of open cluster M44, the Beehive, at around 00:20 UT.

Thursday ▶

16 The Moon is now heading off into the morning sky, giving a good opportunity to view the magnificence of Orion, the Hunter, including the superb spectacle of Orion's Sword. This impressive constellation is due south at 22:00 UT mid-month.

Saturday ▶

18 Mars meets its rival this morning. Shining away at mag. +1.5, the Red Planet will appear just 4.7° north of mag. +1.0 Antares.

Monday

20 This morning there's a lovely grouping of mag. +1.4 Mars, mag. +1.0 Antares and a 21%-lit waning crescent Moon.

Tuesday

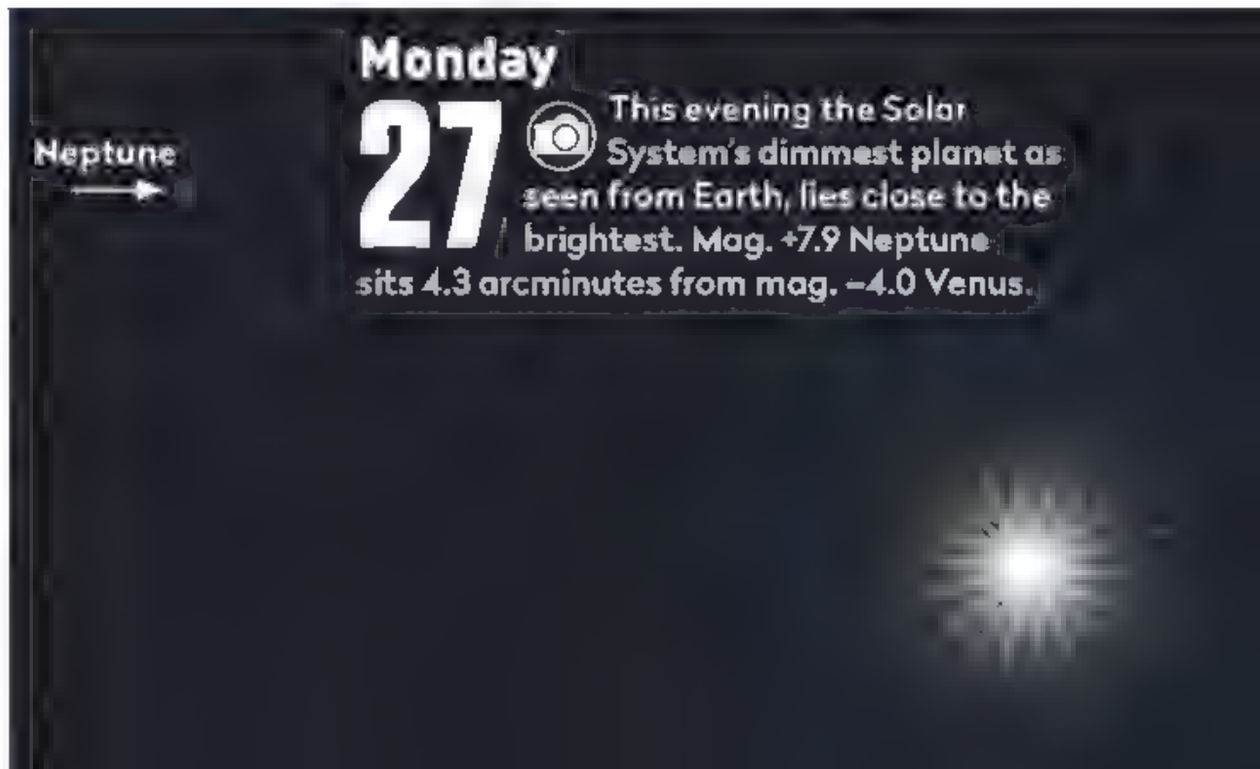
21 With the Moon now in the dawn sky, this is a great time to enjoy the wonders of our Deep-Sky Tour on page 56. This month we're investigating some of the objects located in the constellation of Canis Major.

Saturday

25 There is a slim chance of seeing a very slender, less than 1%-lit waxing lunar crescent this evening. This tricky Moon lies 2.5° below mag. –1.0 Mercury, low in the southwest immediately after sunset.

Sunday

26 Comet C/2017 T2 PanSTARRS will be passing the Double Cluster in Perseus tonight and over the next few nights. This creates a perfect opportunity for a photograph. See page 47.



Monday

27 This evening the Solar System's dimmest planet as seen from Earth, lies close to the brightest. Mag. +7.9 Neptune sits 4.3 arcminutes from mag. –4.0 Venus.

PETE LAWRENCE X 8

Monday

6 This evening our Moonwatch target is well presented. Turn to page 52 to find out more about the crater Gruithuisen.

Friday ▶

10 This evening's full Moon will pass through the weak outer part of Earth's shadow in space giving rise to a penumbral lunar eclipse. Difficult to see visually, this event may be possible to record with a camera. See pages 46 & 76.

Thursday ▶

23 This morning sees the now 2%-lit waning crescent Moon sitting 3.3° to the southeast of mag. –1.7 Jupiter. Both objects can be seen low in the southeast in the dawn twilight around 07:40 UT.

Tuesday

28 At 15:15 UT the 12%-lit waxing crescent Moon lies 4.9° southeast of mag. –4.0 Venus. The Moon will be 27° up, due south in the daylight sky.

Later, catch the pair 5.4° apart in the evening sky.

Family stargazing

The constellation of Orion is one of the most recognisable. This month it's well placed in the early evening except on 3–14 January, when the Moon will spoil the view. Introduce the constellation to younger eyes by showing what it looks like on a star chart, highlighting the three Belt stars in the main pattern's centre. Outside, set the challenge of finding the Belt in the real sky. Once found use this as a starting point for the rest of the constellation, including Orion's Sword.
If you have binoculars or a scope identify the glowing nebula at the Sword's heart. **www.bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY
If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

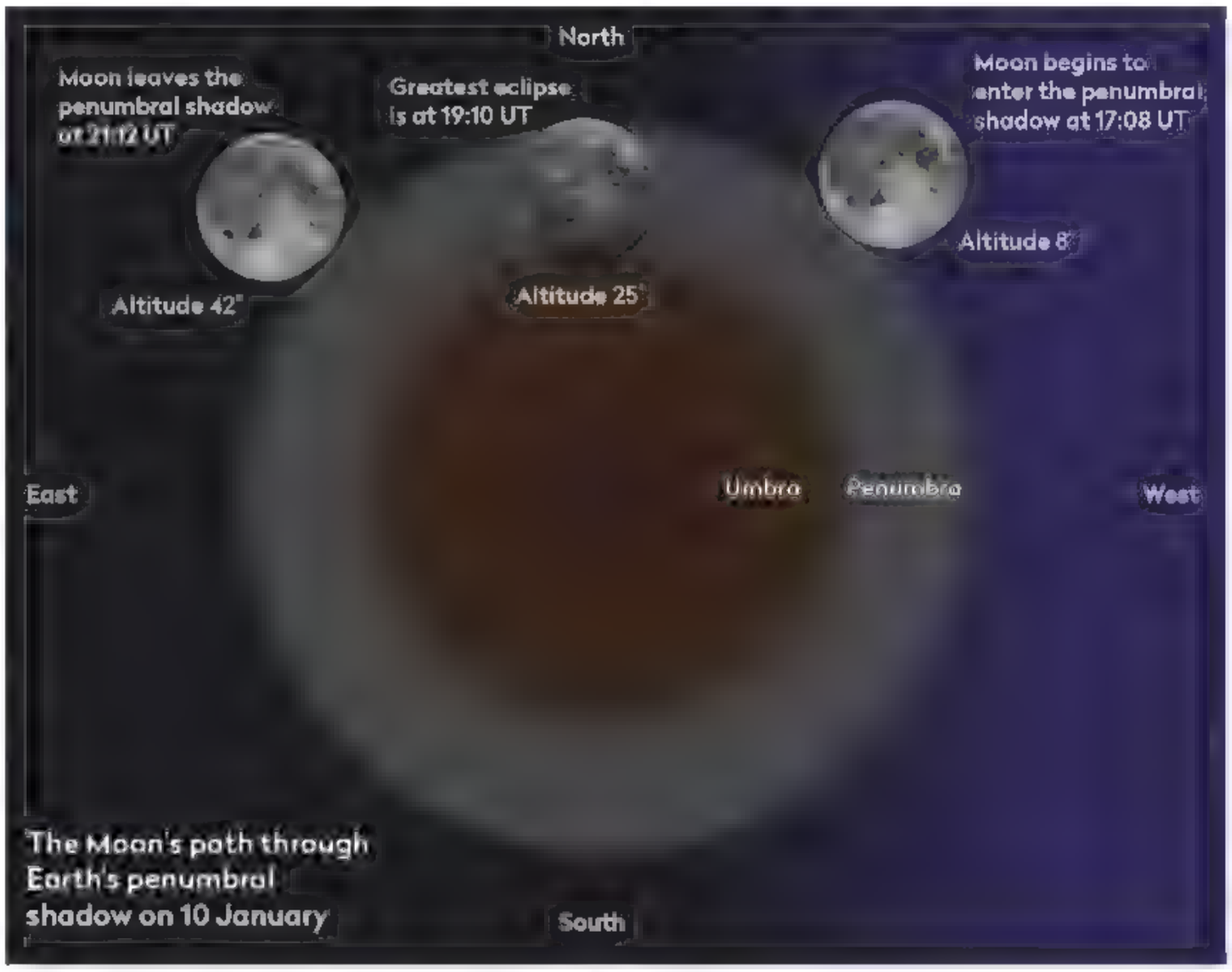
THE BIG THREE

The three top sights to observe or image this month

DON'T MISS

Penumbral lunar eclipse

BEST TIME TO SEE: 10 January, at 19:10 and 21:10 UT (for comparison)



The Moon's path through Earth's penumbral shadow on 10 January

Compare two images of the Moon's disc before and after the eclipse to reveal the penumbra beautifully

The Moon passes through Earth's penumbral shadow on 10 January, producing a penumbral lunar eclipse. Any shadow cast by an object from an extended light source has two components; a dark, inner, umbral shadow and a lighter, outer, penumbral shadow. With an apparent diameter around half a degree, the Sun is an extended light source and Earth's shadow has two parts to it; a dark umbra and weaker penumbra.

Umbral lunar eclipses are visually impressive. Rather than being completely dark, Earth's umbra is infilled with light refracted by our planet's atmosphere. This light's blue component is scattered away leaving the umbra a dark orange-red-brown colour. If you were lucky enough to see the total lunar eclipse on 21 January last year, you will have seen this beautiful colour. If Earth had no atmosphere, Earth's umbral shadow would be completely dark.

The penumbral shadow is completely different and it's important to realise that it doesn't produce the visual spectacle you get with a partial or total umbral eclipse of the Moon. The darkness of the penumbra becomes deeper the closer you get to the edge of the umbra. At the extreme outer edge, from the vantage point of the Moon only a tiny part of the Sun's disc would appear clipped by Earth.

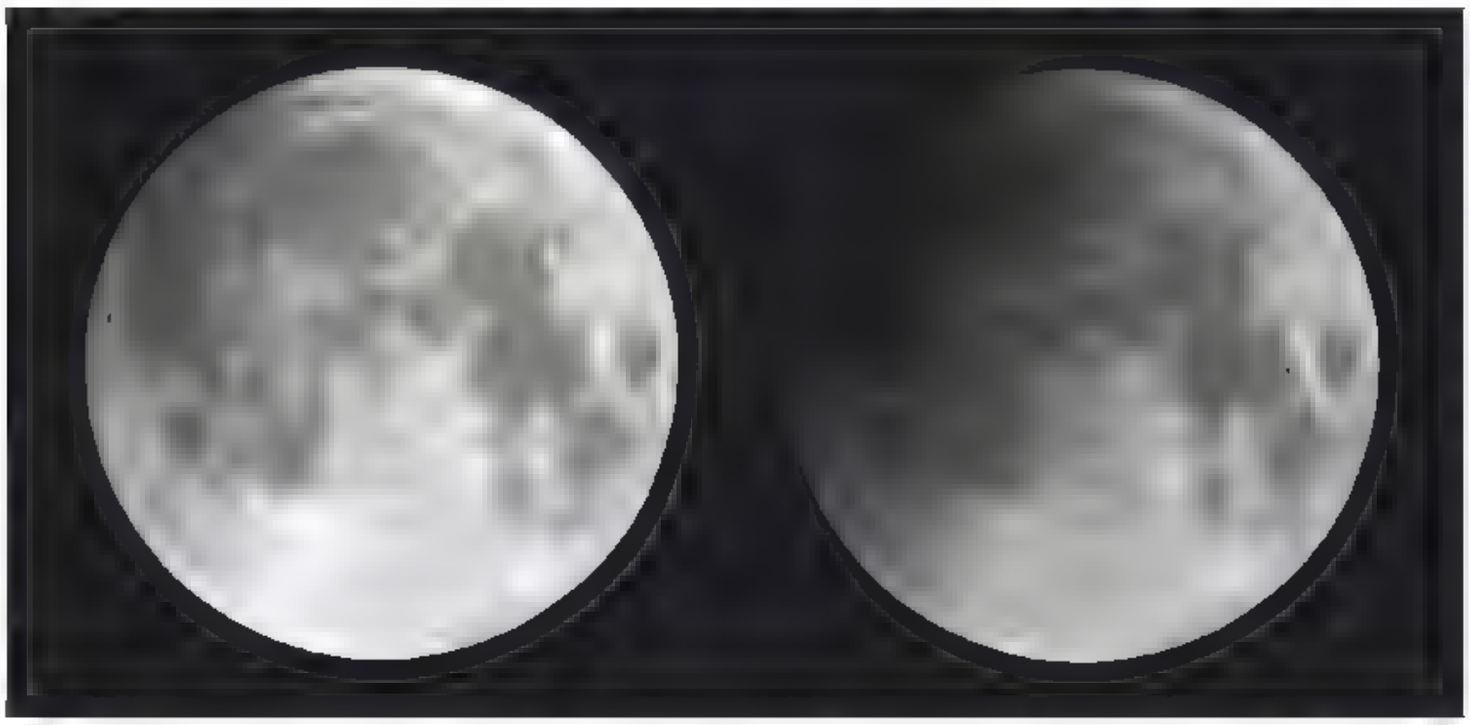
However, as you move closer toward the umbra, looking back from the Moon you'd see increasing amounts of the Sun's disc blocked from view. The penumbral shadow therefore creates a weak gradient across the Moon's disc.

The Moon enters Earth's penumbra at 17:08 UT on Friday 10 January. This is unlikely to be noticed. It's only when the Moon passes closest to the umbral shadow (but not inside it) that one edge begins to appear slightly darker than normal. The maximum eclipse occurs at 19:10 UT and it's the Moon's southern limb which will be closest to the umbra.

As a result, the bright lunar highlands sometimes referred to as the 'lunar badlands' because it's a region so heavily pock-marked with craters, will appear slightly darker than normal. The Moon leaves the penumbral shadow at 21:12 UT marking the end of this penumbral eclipse.

You can see the effects of a penumbral eclipse visually, but they creep up on you so slowly and the shading is so slight, that it's easily missed. Perhaps a more reliable way to record such an event is by using a camera. Comparing two correctly exposed images of the Moon's disc before and after the eclipse will reveal the penumbra beautifully.

▸ **For details on imaging see page 76**



ALL PICTURES PETE LAWRENCE

▲ **A penumbrally eclipsed Moon (right) versus a regular full Moon (left); the shading is subtle**

C/2017 T2 PanSTARRS and the Double Cluster

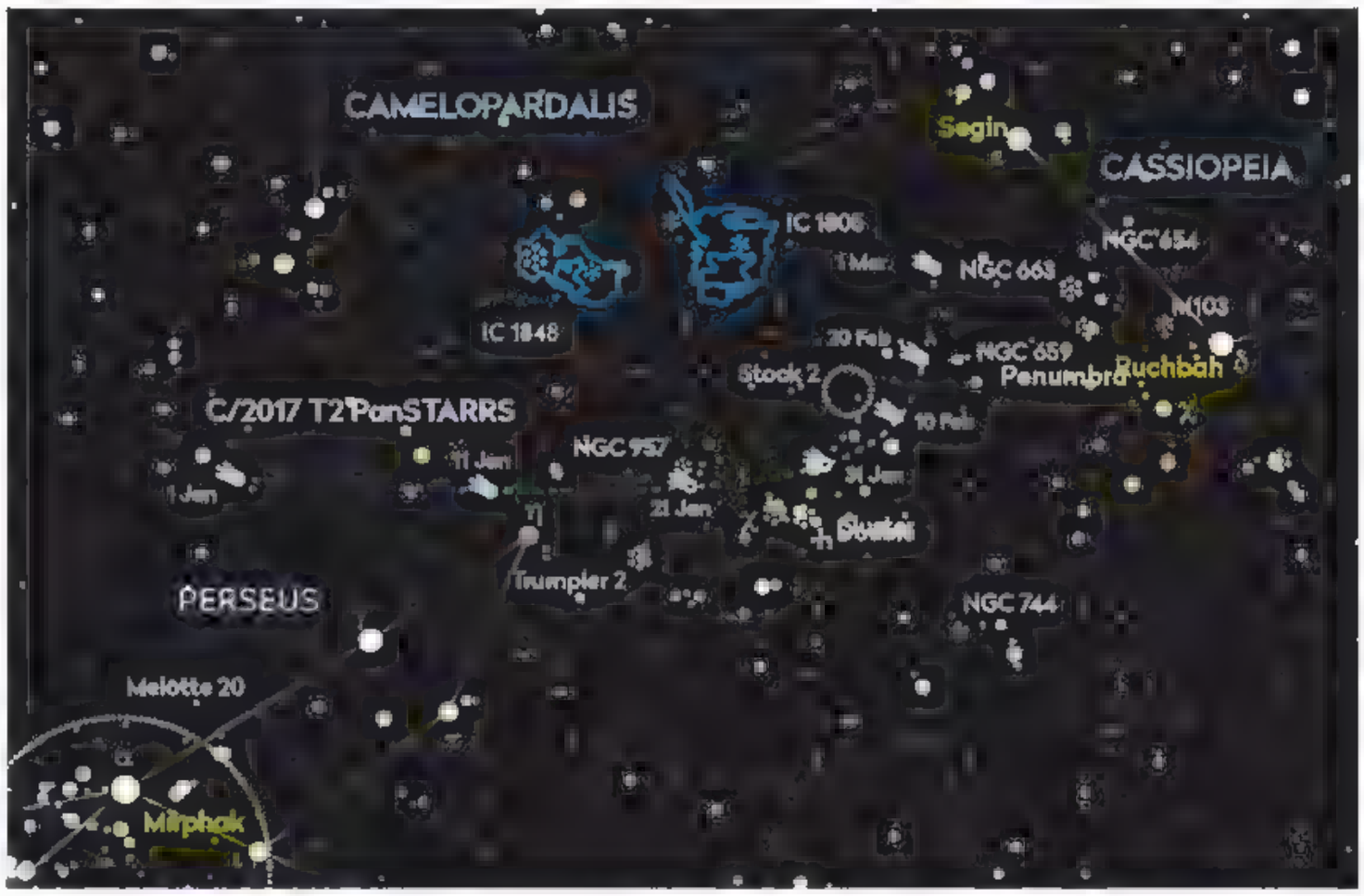
BEST TIME TO SEE: 25–31 January

Comet C/2017 T2 PanSTARRS continues its trek across the UK's night sky being very well placed not far from Polaris. The comet is still increasing in brightness but is unlikely to become a naked-eye affair as was tentatively touted some months ago when it appeared closer to the Sun. At that time, a whole range of possibilities were put forward for the possible peak brightness.

Closest approach to Earth was at the end of last month but perihelion isn't until May 2020. This is when the comet will appear at its brightest. Current predictions have it approaching mag. +10 at this time, so potentially a binocular object but even that might be pushing things under light polluted skies.

This month sees the comet getting close to mag. +10.7, but by virtue of its path taking it close to the Double Cluster in Perseus, it presents an imaging opportunity.

The comet starts the month in Perseus approximately 5° north of Mirphak (Alpha (α) Persei). It tracks west-northwest towards the Double Cluster, h and Chi (χ) Persei, before making a sharp turn northeast during February.



▲ **The path of the comet presents a photo opportunity near the Double Cluster on 24 January**

The closest approach to the Double Cluster occurs at the end of the month on the nights of 24/25 January, through to 30/31 January. As it performs its turn at the start of next month, it appears to slingshot around the large open cluster known as Stock 2, informally known as the 'Muscleman Cluster'. It gets this title because through binoculars it looks like a headless figure flexing its muscles.

As luck would have it, the Moon will be new on 24 January when the comet is closest to the Double Cluster. Although it's not the brightest comet ever, its relatively good position and proximity to this popular deep-sky target will make it a great target towards the end of the month.

Favourable Quadrantids

BEST TIME TO SEE: After moonset on 4 January, 01:10 – 06:30 UT

The astronomical New Year gets off to a bang with the Quadrantid meteor shower, which peaks on the night of 3/4 January. Traditionally viewed as cold and being close to the end of the holiday season, it can take a bit of effort to get outside and observe the shower.

If you do venture outdoors, there are several things worth bearing in mind to get the best from it. The Quadrantid peak ZHR (Zenithal Hourly Rate) is high at around 120 meteors per hour and the shower radiant – the point in the sky where the meteors appear to emanate from – is circumpolar, never setting from the UK.

Visually observed rates are affected by many things including radiant altitude. Early evening the Quadrantid radiant is just a few degrees above the northern horizon and a first quarter Moon will be up, spoiling the show.

Things do improve, as the Moon sets around 01:10 UT on 4 January and the Quadrantid radiant altitude will be high as dawn begins to break. The shower shows a sharp rise to a peak rate over a few hours, the peak being expected at 08:20 UT on the 4th. It's the run up to dawn on the 4th that should give the best results. Astronomical darkness ends at 06:20 UT.

THE PLANETS

Our celestial neighbourhood in January

PICK OF THE MONTH

Venus

Best time to see: 31 January, from 17:00 UT
Altitude: 13°
Location: Capricornus
Direction: Southwest
Features: Phase, subtle disc shadings
Recommended telescope: 75mm or larger

Spectacular Venus is currently an evening object, shining at mag. –3.9. The planet's position is improving due to the plane of the ecliptic making a steeper angle relative to the western horizon at sunset. As the main planets appear close to this plane, it means that any such objects which are close to the western horizon after the Sun has gone down will appear higher and last longer before setting.

This is demonstrated by an increase in the setting time after sunset. At the start of the month Venus sets three hours after the Sun. By the end of the month this value will have extended to nearly four hours.

Being above the horizon for longer after sunset allows Venus to appear against a darker background sky and this is when, visually at least, the planet really is spectacular. At the start of January this occurs when Venus is relatively low with just 5° of altitude. By the end of January, things improve and Venus appears around 15° up when the sky becomes truly dark.

Ironically, being so bright, looking at Venus through a telescope when it's in a truly dark sky introduces problems of contrast, not to mention poor seeing due to low altitude. The best views are either during the day or just as twilight is starting to darken the sky. Through a telescope Venus currently shows a gibbous phase, 81-% illuminated on 1 January, 73%-illuminated on 31 January.

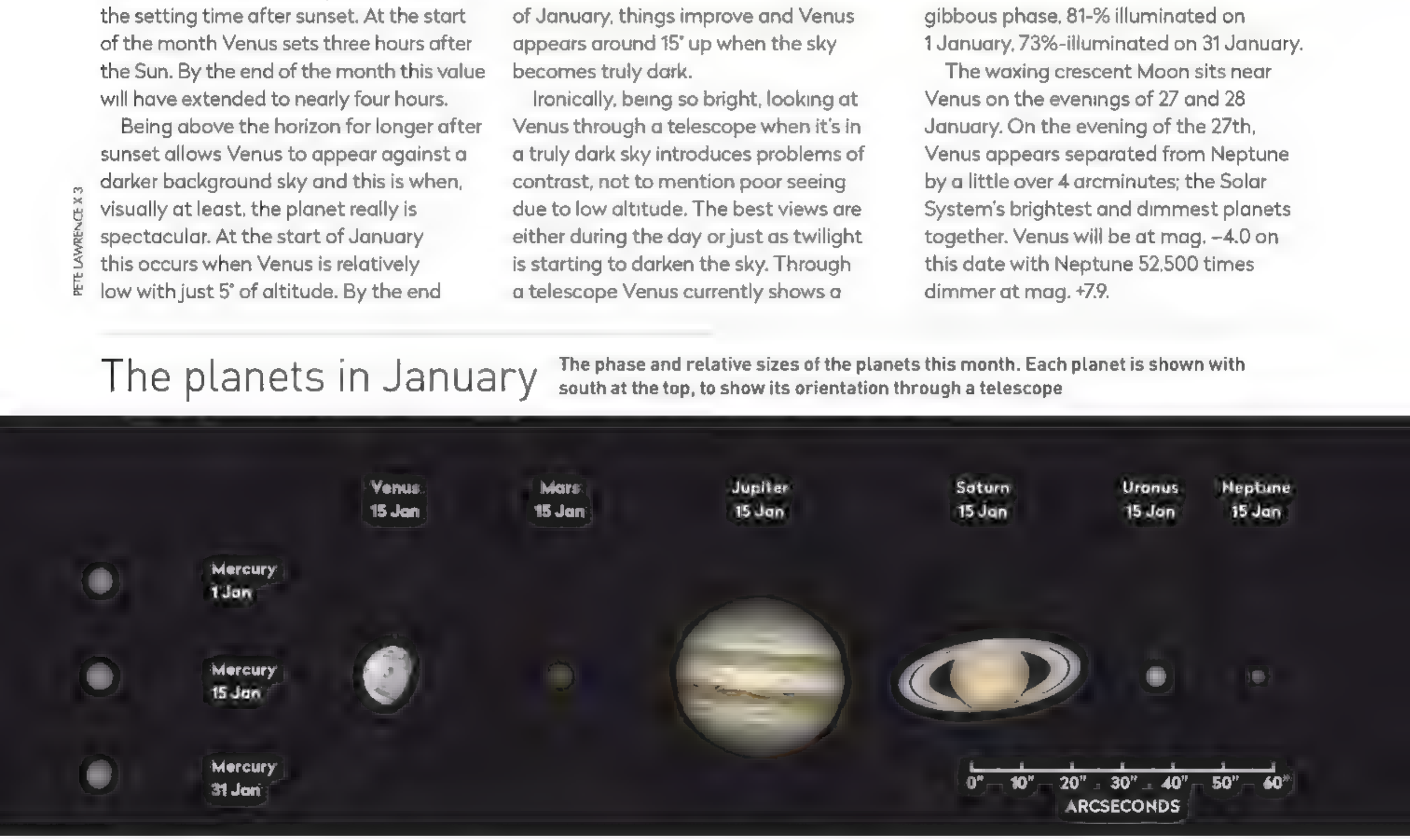
The waxing crescent Moon sits near Venus on the evenings of 27 and 28 January. On the evening of the 27th, Venus appears separated from Neptune by a little over 4 arcminutes; the Solar System's brightest and dimmest planets together. Venus will be at mag. –4.0 on this date with Neptune 52,500 times dimmer at mag. +7.9.

▲ **The position of Venus, Mercury and the Moon relative to the southwest horizon at 18:00 UT on January dates shown. The apparent size of the Moon has been exaggerated for clarity**

PETE LAWRENCE X 3

The planets in January

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 31 January, 40 minutes after sunset
Altitude: 4.5° (very low)
Location: Capricornus
Direction: West-southwest
Not visible until the last week of January when it appears low in the southwest sky after sunset. As seen from the UK, a thin waxing crescent Moon sits 2.5° below mag. –1.0 Mercury on 25 January but both objects are low. Mercury sets 70 minutes after the Sun on 31 January shining at mag. –0.9 and 85%-lit. On the 31st Mercury will appear separated from Venus by 26°.

Mars

Best time to see: 31 January, 18:00 UT
Altitude: 6° (low)
Location: Ophiuchus
Direction: Southeast
Orange Mars is currently a morning object located in the southern part of Ophiuchus. Telescopically, the planet isn't much to look at but this will improve as the distance between Earth and Mars decreases. On 1 January Mars shines at mag. +1.6 and presents a 4 arcsecond disc, 95%-lit through the eyepiece. On the 17th, Mars sits 4.8° north of the star Antares. A waning crescent Moon sits 6.7° west-northwest of Mars on the 20th.

Jupiter

Best time to see: 31 January, from 07:15 UT
Altitude: 3° (very low)
Location: Sagittarius
Direction: Southeast
Jupiter is a morning planet that appears rather close to the Sun at the start of January. By the month's end, mag. –1.7 Jupiter will rise 1.3 hours before the Sun. A slender waning crescent Moon sits near Jupiter on the morning of the 22nd, the 6%-lit crescent appearing 9.7° to the west of Jupiter. On the morning of the 23rd, the now 2%-lit waning crescent Moon sits 3.3° to the east-southeast of Jupiter.

Uranus

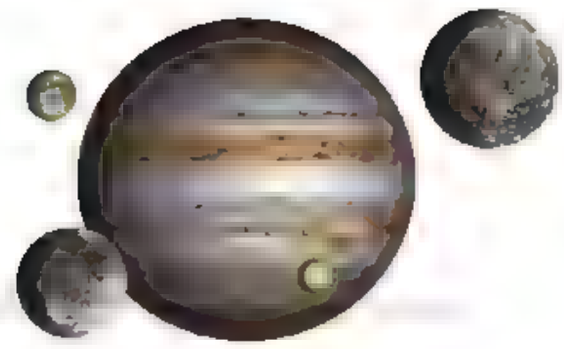
Best time to see:
1 January, 19:10 UT
Altitude: 49°
Location: Aries
Direction: South
Uranus is an evening planet, which appears well positioned at the start of January, able to reach its highest point in the sky, due south, in darkness early evening, around 19:30 UT. By the end of the month, the planet loses this ability, being slightly to the west of south as darkness falls. At mag. +5.8, in theory at least it should be possible to see Uranus with the naked eye. You'll need a good, dark sky to do this. Through a telescope it's Uranus's green tint that catches the eye: it's rather striking.

Neptune

Best time to see:
1 January, 18:20 UT
Altitude: 27°
Location: Aquarius
Direction: South-southwest
Lying 46° further to the west than Uranus, Neptune's position in the January sky deteriorates. Where Uranus appears at its highest point due south in darkness at the month's start, Neptune is to the west of south. By the end of the month, mag. +7.9 Neptune is just 12° up above the west-southwest horizon as true darkness falls. A meeting between Venus and Neptune on the 27th sees both planets separated by just 4 arcminutes. You'll need a scope, binoculars, or a camera to see this.

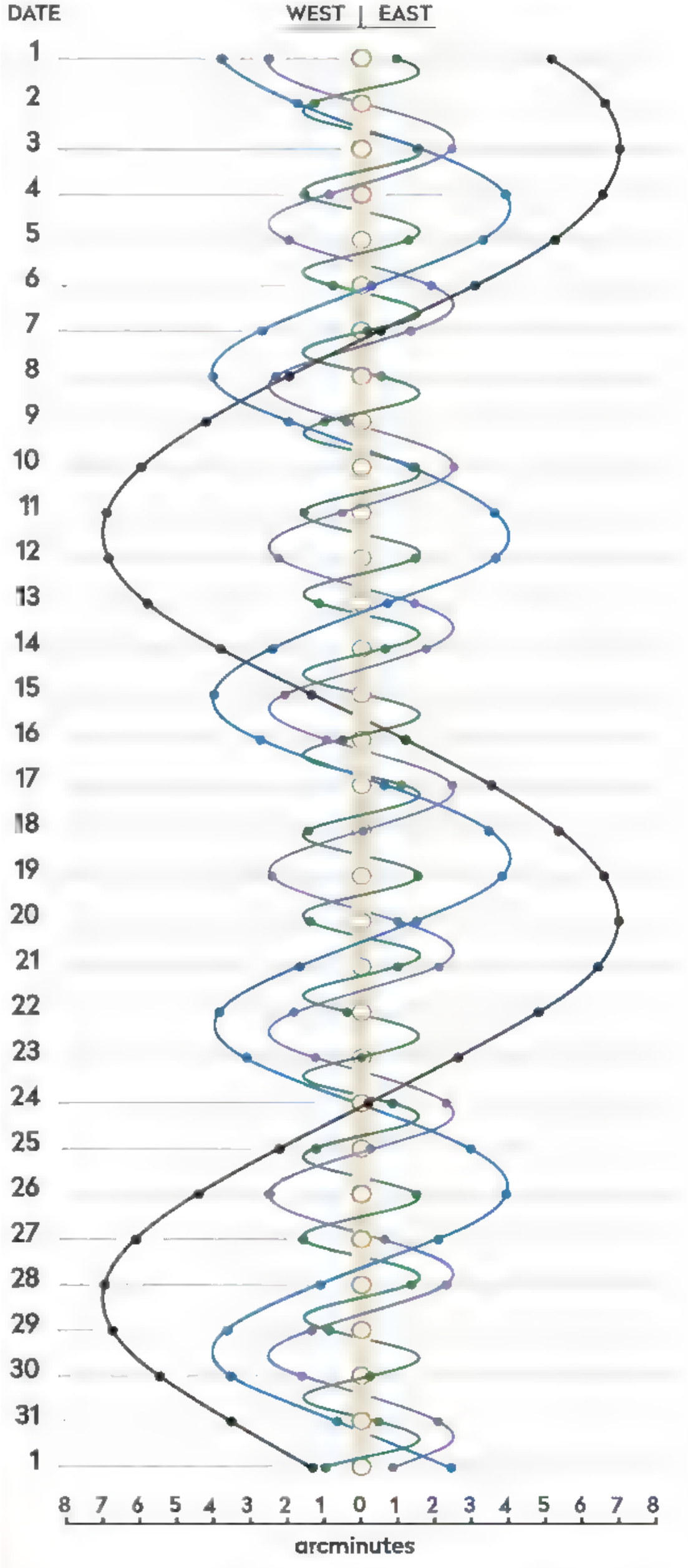
NOT VISIBLE THIS MONTH:
Saturn

More **ONLINE**
Print out observing forms for recording planetary events



JUPITER'S MOONS: JANUARY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – JANUARY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

CHART PETE LAWRENCE

When to use this chart

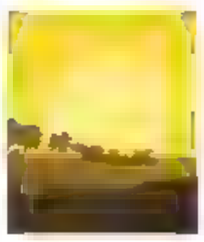
1 January at 00:00 UT
15 January at 23:00 UT
31 January at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

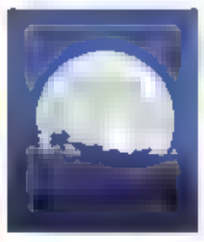
1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in January*



Date	Sunrise	Sunset
1 Jan 2020	08 26 UT	16.01 UT
11 Jan 2020	08:22 UT	16.14 UT
21 Jan 2020	08.12 UT	16 31 UT
31 Jan 2020	07 58 UT	16 50 UT

Moonrise in January*

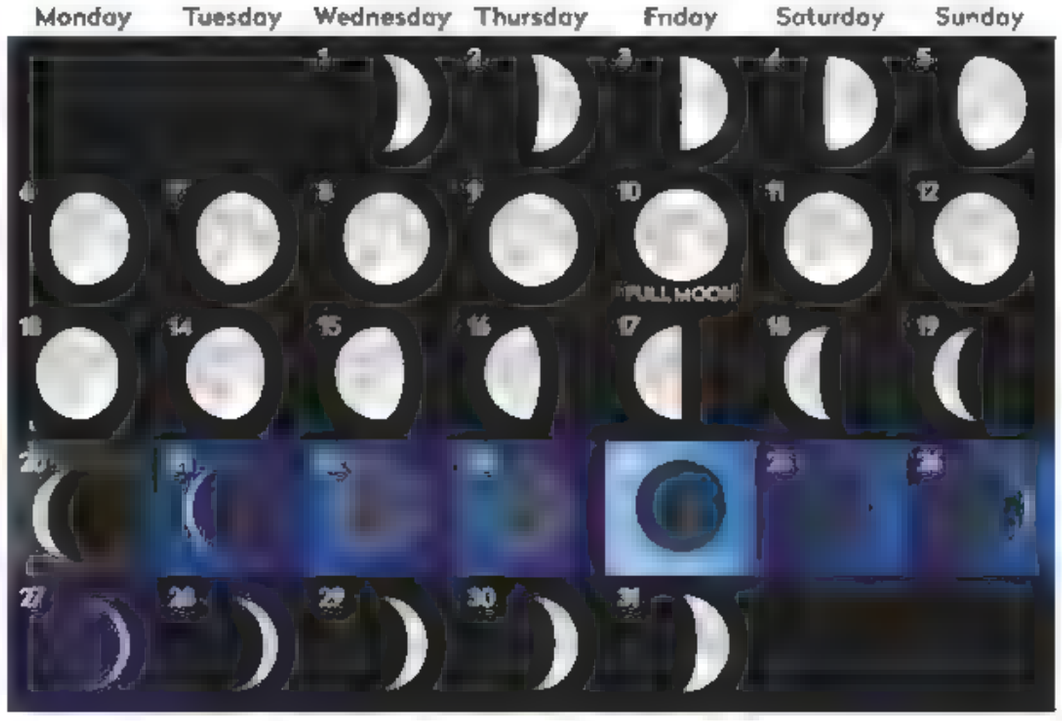


Moonrise times

1 Jan 2020, 11.50 UT	17 Jan 2020, 00:01 UT
5 Jan 2020, 12:51 UT	21 Jan 2020, 05.20 UT
9 Jan 2020, 14.53 UT	25 Jan 2020, 08.48 UT
13 Jan 2020, 19.48 UT	29 Jan 2020, 10.11 UT

*Times correct for the centre of the UK

Lunar phases in January



MORE **ONLINE**

Paul and Pete's night-sky highlights

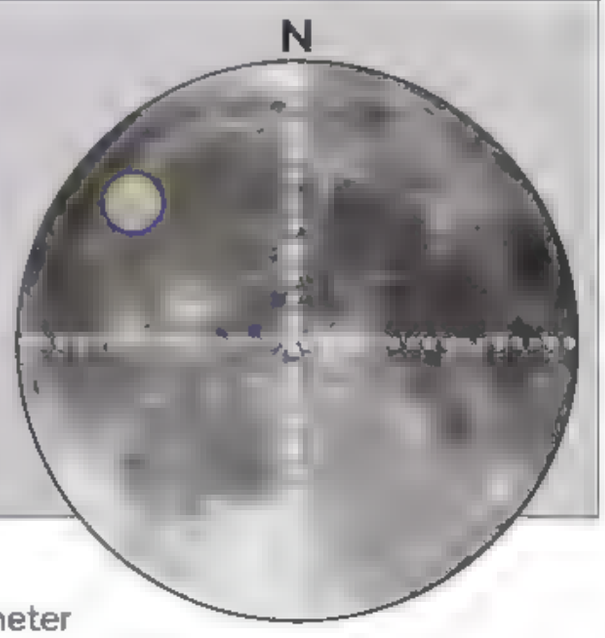
Southern Hemisphere sky guide

MOONWATCH

January's top lunar feature to observe

Gruithuisen

Type: Crater
Size: 17km
Longitude/latitude: 39.8° W, 32.9° N
Age: Between 1.1–3.2 billion years
Best time to see: Three days after first quarter (5–6 January) and two days after last quarter (20 January)
Minimum equipment: 100mm refractor



PETE LAWRENCE X 5

Despite its diminutive size, the 17km diameter crater **Gruithuisen** is straightforward to locate. This is due to it being positioned in an easy to identify part of the Moon and the crater being surrounded by flat lava plains. It lies off the south of the highlands, which arch west along the northern shores of **Mare Imbrium**. As they do, they brush past the beautiful Sinus Iridum, the Bay of Rainbows, following a southern track before petering out to the south of the 40km crater Mairan.

The boundary between the southern edge of the highlands and the flat lava plains that lie beyond is irregular as the elevated highland features are gradually invaded by lava 'lakes'. Gruithuisen lies beyond this transition region in the lava that forms the boundary between Mare Imbrium and **Oceanus Procellarum**.

The Gruithuisen crater has a well-defined rim that leads down to an unremarkable floor. Under oblique lighting with larger instruments, it may be possible to see that the floor isn't evenly illuminated, the result of various undulating bumps inside the crater. The crater's shape is mostly circular but stretched slightly towards the south.

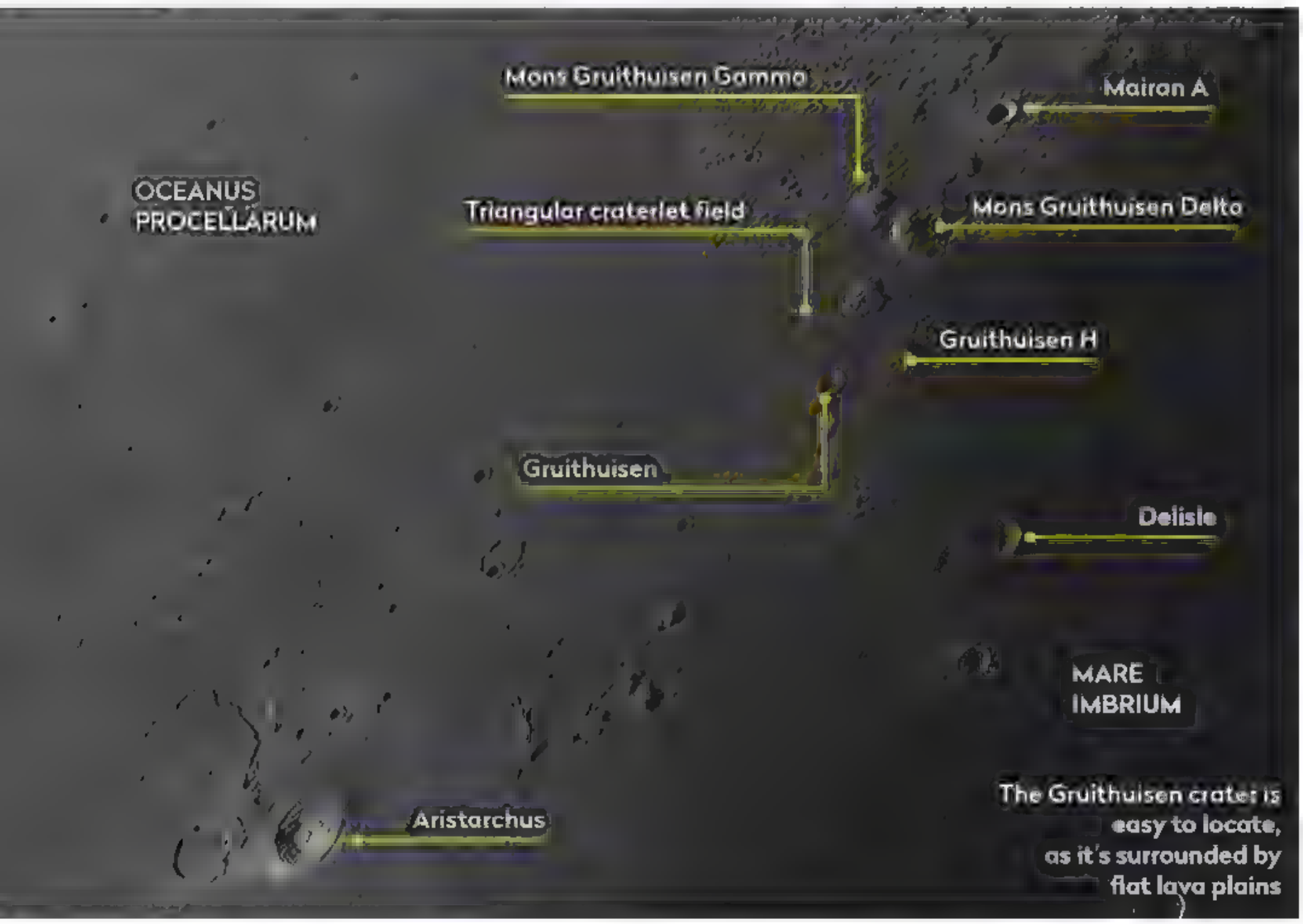
Again, under oblique illumination the surrounding lava reveals a number of north-south running wrinkle ridges. Look 60km to the east of Gruithuisen during the Moon's waning crescent phase and there's also a hint of an unnamed submerged 40km ghost crater. The 6km crater **Gruithuisen H** sits to the north of this ephemeral feature, in the raised area to the east of Gruithuisen.

Immediately north of the main crater is a triangular rocky outcrop. Mid-way between the southern end of the outcrop and Gruithuisen is a **triangular patch of lava** that appears to be differently coloured through most amateur scopes. However, this patch is interesting because it is entirely formed from tiny craterlets which range in size from 1km across and smaller. The clustering is most impressive when examined on high resolution images and is thought to have occurred when an incoming body broke up before the point of impact. If you're into lunar imaging an interesting challenge is to image this 14x7km region and see whether you can resolve any of the individual craterlets.

The Gruithuisen crater is mostly circular but stretched slightly towards the south

Keep heading north and you'll arrive at two rounded features known as **Mons Gruithuisen Gamma** (γ) and **Mons Gruithuisen Delta** (δ). These are known as the Gruithuisen domes, and are excellent examples of this type of lunar feature. They act like a gateway to a thin region of lava that heads to the north, passing west of 16km **Mairan A**. The domes are similar in size, 20km across and nearly a kilometre high. They are sometimes described as resembling upturned bath tubs, an odd yet fitting description. Delta sits to the east, Gamma to the west.

Located 150km to the southeast of Gruithuisen is the 25km crater **Delisle**. South of Gruithuisen you'll find isolated mountain complexes and small craters peppering the lava before you arrive at the complex region around the Moon's brightest crater, 40km diameter **Aristarchus**.



COMETS AND ASTEROIDS

Catch asteroid 5 Astraea as it reaches opposition near the Beehive Cluster, M44

Asteroid 5 Astraea comes to opposition this month, well positioned in the constellation of Cancer the Crab, not too far from the Beehive Cluster, M44. The opposition date is 21 January when Astraea will shine at mag. +8.9, placing it within reach of binoculars and small scopes.

It appears brighter than mag. +10.0 all month, beginning its track across the southern part of Cancer approximately 1.4° to the north-northwest of mag. +5.6 45 Cancri. This is located within the main inverted bottom 'V' portion of the constellation. It then heads northwest brightening from mag. +9.6 on 1 January to reach +9.0 by 20 January. At 00:00 UT on 22 January, the mag. +8.9 asteroid lies 1.3° south of the mag. +6.1 star 25 Cancri.

5 Astraea, as its number suggests, was the fifth such body discovered and represented something of a milestone in asteroid observing. The first four asteroids, 1 Ceres, 2 Pallas, 3 Juno and 4 Vesta, were all discovered within a narrow period from 1801–07. With no other such bodies found for many years after this, the natural assumption started to creep in that the so-called 'Big Four' were unique. Just 38 years after the discovery of Vesta, on 8 December 1845, Karl Ludwig Hencke blew that assumption out of the water by discovering 5 Astraea. This discovery then opened the door to the discovery of the multitude of asteroids we know about today.

5 Astraea has a mean diameter of 119km, measuring 167x123x82km in size. It's an S-type, or siliceous, asteroid with a high albedo of 22.7 per cent. At favourable oppositions it can shine at mag. +8.7. It takes 4.13 years to complete an orbit around the Sun. Its orbit is elliptical varying the distance of 5 Astraea from the Sun from 2.1 AU to 3.1 AU.

STAR OF THE MONTH

Bellatrix, Orion's female warrior

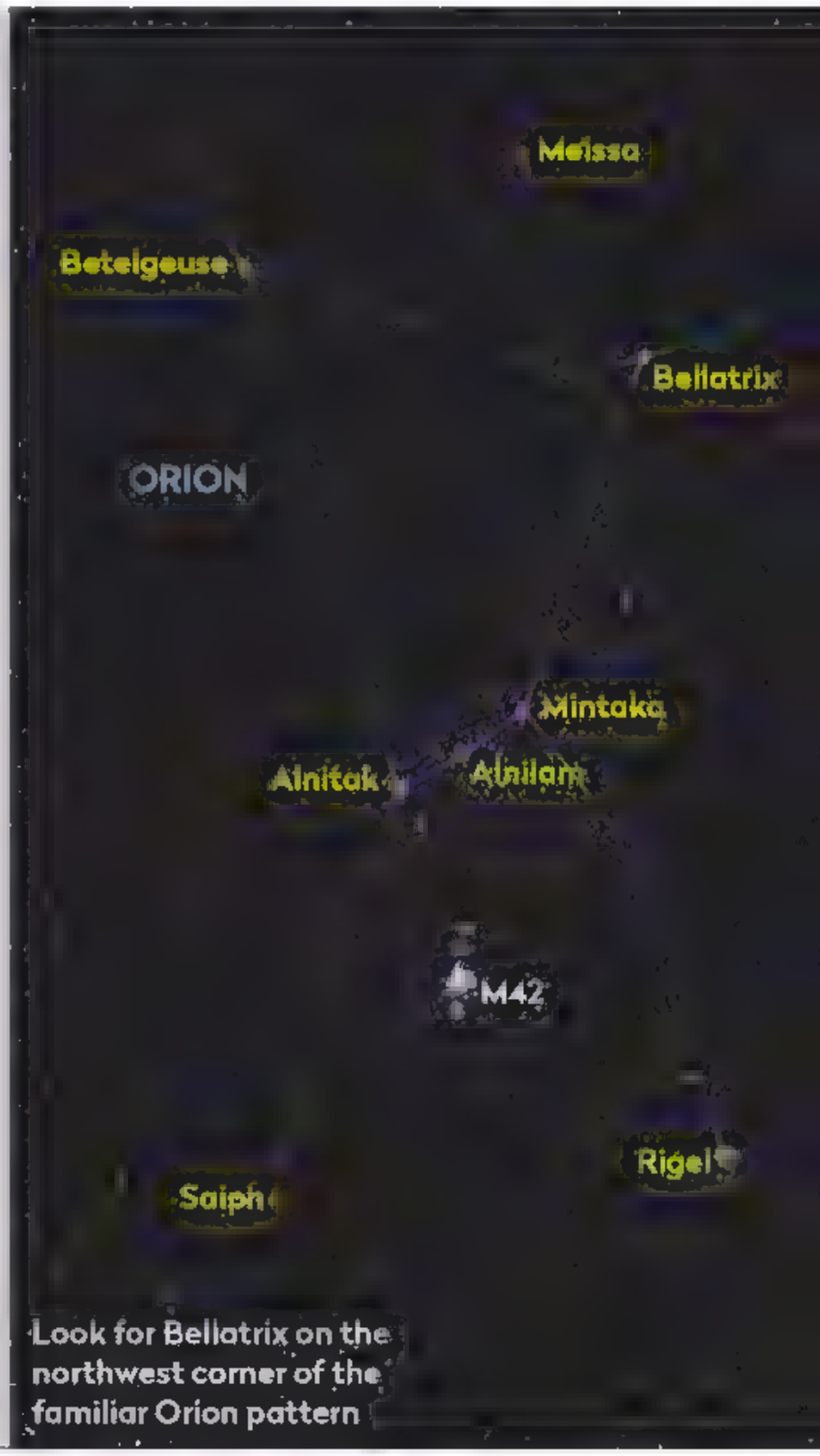
The familiar pattern of Orion contains a number of favourite stars. The three that form his belt are obvious, as is bright orange Betelgeuse (Alpha (α) Orionis) in the northeast corner and bright blue-white Rigel (Beta (β) Orionis) in the southwest corner. The third brightest star in Orion is Bellatrix (Gamma (γ) Orionis), which marks the northwest corner of the main pattern.

Bellatrix is a B2 III type star, B2 indicating it's a hot blue coloured star. Its temperature is 22,000K, some 3.7 times hotter than our own Sun. The III indicates that it's a giant star although it's actually a hydrogen-fusing dwarf with a mass equivalent to nine Suns. With an estimated age of 20 million years, it's expected that Bellatrix's hydrogen will run out in 7 million years. It will then evolve into a class of star known as a subgiant before becoming a giant.

For a long time, Bellatrix was thought to be part of the Orion association to which many of the O and B type stars visible in the constellation belong. However, with a revised distance estimate it is now known that Bellatrix is roughly one-quarter the distance of the association and is therefore a foreground star, 250 lightyears distant.

The apparent diameter of Bellatrix has been measured directly to be 0.00072 arcseconds. Combined with its known distance of 250 lightyears it is possible to work out that the star's physical diameter is around six times that of our Sun. Its mass (equivalent to 9 solar masses) means that Bellatrix is on the threshold of the limit beyond which it'll end its life as a supernova. It's more likely it will end up as a large white dwarf, close to the limit of 1.4 solar masses for such objects.

The name Bellatrix translates as 'female warrior' and was the original name of the star Capella (Alpha (α) Aurigae). It moved to Gamma Orionis in the 15th century.



Look for Bellatrix on the northwest corner of the familiar Orion pattern

BINOCULAR TOUR With Steve Tonkin

Discover a Leaping Minnow, a trio of clusters and The Crab and California Nebulae

1. The Queen of Clusters, M35

10x 50 First of all identify the mag. +4.2 1 Geminorum and look a little less than 2° to the northeast, where you will find an obvious misty patch about the same size as the Moon. On a good night, you ought to be able to resolve a dozen stars in your 10x50s. Also try using averted vision to see if you can glimpse open cluster, NGC 2158, which is half a degree towards 1 Geminorum. ☐ **SEEN IT**

2. Telescopium Herschelii

10x 50 In 1789, Vienna Observatory director Maximilian Hell, honoured William Herschel's discovery of Uranus by commandeering a region of Auriga and Lynx and naming it for Herschel's telescope. The brightest stars are the 5th magnitude Psi (ψ) Aurigae group. It's a rewarding region to scan with binoculars, owing to the variety of colours among the brighter stars. The small blur just south of ψ-7 Aur is open cluster NGC 2281. ☐ **SEEN IT**

PETE LAWRENCE X 3

3. Leaping Minnow

10x 50 A little more than 4° east of Hassaleh (Iota (ι) Aurigae), there is a little group of 5th magnitude stars that includes 14, 16, 17 and 19 Aurigae. With your 10x50 binoculars you should be able to reveal that this group of stars forms the shape of a fish. To the northeast of the Minnow you will see the 'Splash', which includes mag. +5.0 Phi (φ) Aurigae. If you include the splash, you should see at least 30 stars. ☐ **SEEN IT**

4. A trio of clusters

10x 50 Put Phi (φ) Aurigae to the right of centre of the field of view and you should see two fuzzy patches, one above and one below the centre. The upper, slightly larger and fainter one is the Starfish Cluster, M38. The other is M36. Now put M36 near the top right of the field and M37, a larger and brighter fuzzy patch, will be visible near the bottom of the field of view. ☐ **SEEN IT**

5. The Crab Nebula, M1

15x 70 You'll need a dark, transparent sky to see this remnant of SN1054. On 28 August 1758, Charles Messier was seeking the first predicted return of Halley's Comet when he found a comet-like misty patch 1.1° northwest of Zeta (ζ) Tauri. It hadn't moved a week later so he knew it wasn't a comet. M1 became first in his list of objects that may deceive comet hunters. ☐ **SEEN IT**

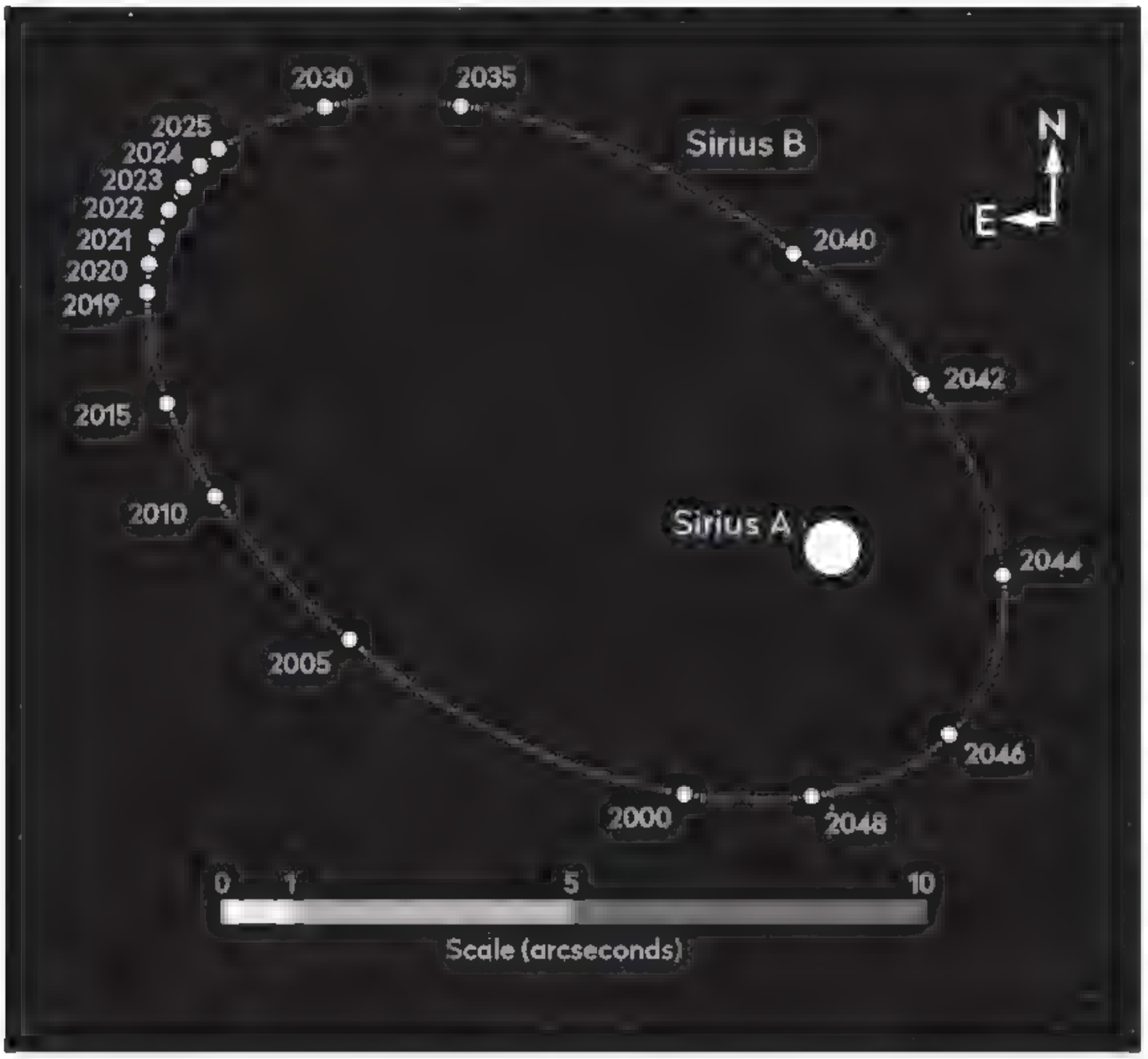
6. The California Nebula, NGC 1499

15x 70 If the sky is good enough for M1 then mount your binoculars. Place mag. +4.0 Menkib (Xi (ξ) Persei) mid-way between the centre and the western edge of the field of view. Use averted vision, periodically tap your binoculars, and look for a variation in sky-brightness, with the elongated brighter patch crossing the central half of the field of view. This is the California Nebula. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

Finding the Dog Star, Sirius A, may be easy, but can you find its nearby Pup, Sirius B?



▲ **The orbit position of the Pup star (Sirius B) relative to Sirius A in the first half of the 21st century. Short exposure, planetary-scale imaging is required to separate the two stars**

There's no mistaking Sirius. It's the brightest night time star, shining at mag. –1.5. If you're able to identify the pattern of Orion the Hunter, you have a ready-made pointer to Sirius. Just follow the line of Orion's Belt southeast, which is down and left towards the horizon as seen from the UK.

If finding Sirius were this month's challenge then we would finish here. The real challenge involves trying to find the physical companion star to the main star, known as Sirius B. As Sirius is often referred to as the Dog star, Sirius B has become known as the Pup. The Pup is a mag. +8.5 white dwarf and despite its relative brightness is considered a serious challenge to see because the brightness of Sirius A basically cloaks its companion.

The brightness of Sirius is slightly misleading. It cements its place at the top of the night time stellar magnitude scale by virtue of its proximity to the Sun. It lies at a distance of 8.6 lightyears, which makes it one of our closer neighbours. Sirius A and B have a mutual orbit, which takes 50 years to complete. The orbit is elliptical, with their physical separation varying from 8.2 AU to 31.5 AU (where 1 AU is defined as the current distance from the Earth to the Sun).

From Earth we see the apparent separation vary from a couple of arcseconds to around 11 arcseconds. Over the next decade, the separation will be close to its peak value, producing the best possible conditions for hunting the Pup.

In the next decade the separation will be near its peak, the best setting for hunting the Pup

There have been various suggestions as to the best way to see or image the Pup. You can try placing Sirius A out of the field so you're looking at the area of sky just to the east of it, or try to catch Sirius in twilight. If you time it right, the slightly brighter sky will reduce the dazzling brilliance of Sirius A while still allowing Sirius B to be seen.

It is important to look at our main graphic and take on board the apparent size of the orbit. At around 10.5 arcseconds from its primary, the distance between Sirius A and B is around 20 per cent the maximum apparent size that Jupiter can attain. There are many faint stars that appear close to Sirius A and it's very easy to fall into the trap of thinking you've bagged the Pup when you haven't. A good comparison ruler is the star Nair al Saif (Iota (ι) Orionis) at the bottom of Orion's Sword. It consists of two stars, mag. +2.8 and 7.7, separated by 11 arcseconds. Split this and you're set for Sirius A and B.

DEEP-SKY TOUR

We locate the celestial delights in Canis Major, including the Mexican Jumping Bean Cluster

1 IC 2165

This month's Deep-Sky Tour takes us into the realm of the Great Dog, Canis Major. We start with a tiny planetary nebula catalogued as IC 2165, which is located 5° to the north of mag. +2.0 Mirzam (Beta (β) Canis Majoris). The term 'planetary' is well suited here as the nebula appears as a 9 arcsecond – ie, planetary scale – grey disc. It shines at mag. +10.6 and, due to its size, is easy to overlook if using lower powers. An OIII filter can help with its identification. ☐ **SEEN IT**

2 NGC 2345

Our next target has the unforgettable catalogue number NGC 2345. To locate it we need to move to the east of Canis Major's triangular head, formed from Gamma (γ), Iota (ι) and Theta (θ) Canis Majoris. It sits 2.5° north and 1° east of Gamma (γ) Canis Majoris. This mag. +7.7 open cluster is located within the boundary of the Milky Way, appearing against a rich background of faint stars. A small scope shows around a dozen stars within a hazy patch. A 250mm scope ups it to about 30 stars, while a 300mm scope pushes the count to around 50. An attractive arch of mag. +10–11 orange stars sits in the centre of the cluster. ☐ **SEEN IT**

3 NGC 2359

NGC 2359 is an emission nebula unofficially known as Thor's Helmet, an apt description because its overall appearance is of a domed 'helmet' with faint 'wings' either side. It's formed partially from ionised gas irradiated by a Wolf-Rayet star known as WR7. Wolf-Rayet stars are incredibly hot, having lost much of their outer hydrogen to leave a helium-burning core. Thor's Helmet lies 2.5° east of NGC 2345 and is best suited for 150mm or larger instruments, although we'd recommend a 250mm scope. The first part of the nebula evident through the eyepiece is a rectangular east-west glow. This is one of the helmet's wings. The helmet itself is created from a nebula bubble that sits north of the rectangular glow. The bubble presents itself as a ring visually, with a brighter arc close to its interface with the brighter wing. ☐ **SEEN IT**

▲ Thor's Helmet: NGC 2359 gets its nickname from its distinctive nebula bubble

4 NGC 2374

We keep the line going from NGC 2345 through NGC 2359 for a distance of 1.3° to arrive at out next target, the eighth magnitude open cluster NGC 2374. A 150mm scope shows about 25 stars spread fairly evenly over a 5 arcminute region, elongated in a northeast to southwest manner. Like our previous two targets, NGC 2374 lies within the boundary of the background Milky Way and this does make it tricky to see where the cluster stops and the background begins. ☐ **SEEN IT**

5 M41

M41 has no difficulty standing out from the crowd. This is a beauty of the winter sky, often overlooked because from the UK it's low. However, it's easy to locate M41 as it lies 4° south of Sirius (Alpha (α) Canis Majoris). The cluster has a visual magnitude of +4.5, which makes it a naked-eye object. A small scope reveals a rich object containing around 50 stars brighter than mag. +12.0 spread across an area of similar size to that subtended by a full Moon (30 arcminutes across). Larger instruments extend the richness and size of the cluster to an apparent diameter around 45 arcminutes. A lovely combination of colours can be seen here too, some orange stars mixed in with a majority of blue white stars. ☐ **SEEN IT**

6 NGC 2362

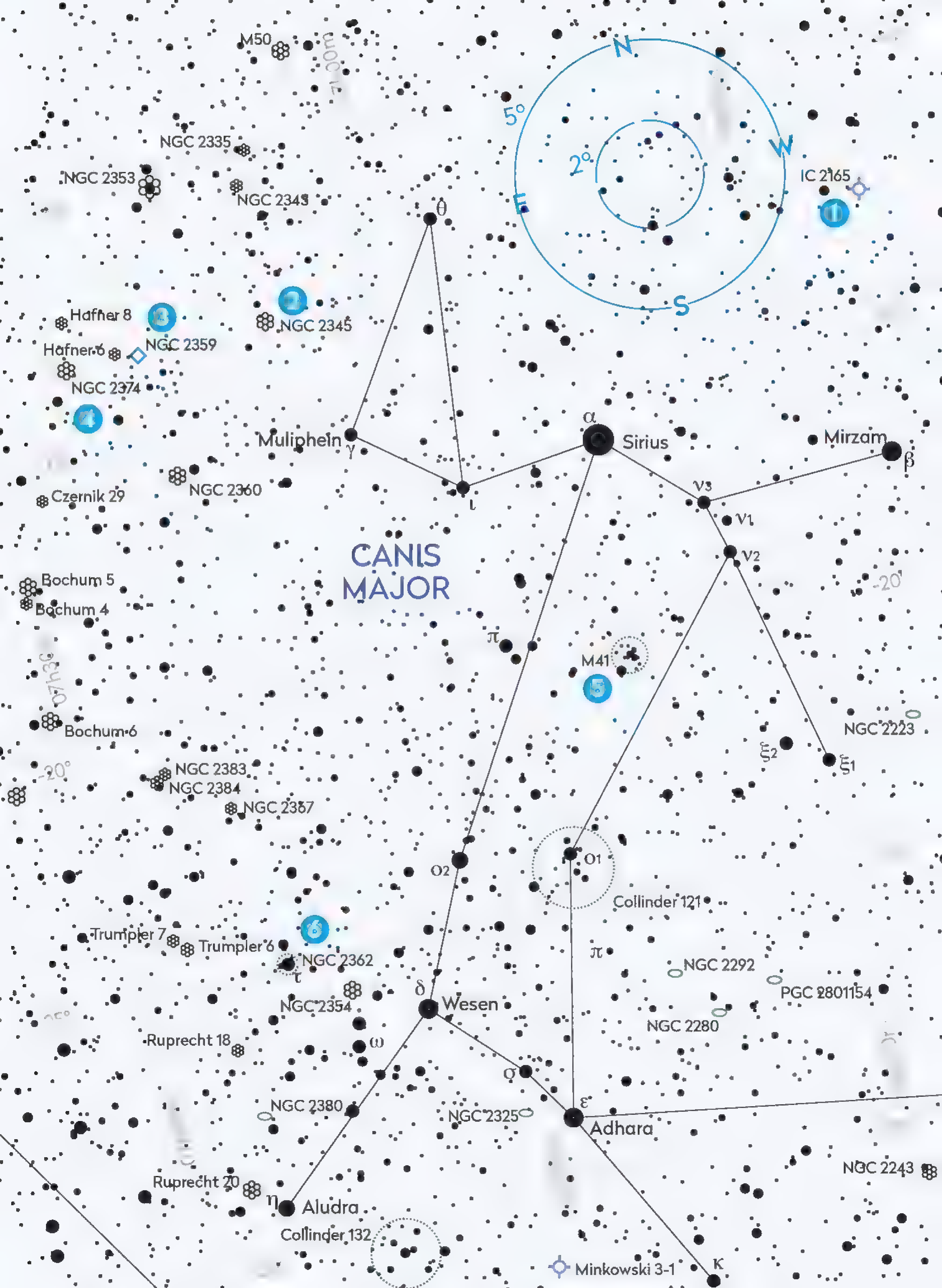
For the final target of this month's tour we head south to mag. +4.3 Tau (τ) Canis Majoris, a triple star located 8.5° southeast of M41 and 2.8° northeast of Wesen (Delta (δ) Canis Majoris). The object we're after surrounds Tau, an open cluster known as NGC 2362 (sometimes known as the Tau Canis Majoris Cluster.) The brightness of Tau causes interference with the view, but perseverance pays off as the cluster is rich. A 250mm scope shows around 40 stars in close proximity to Tau. The real fun starts when you centre Tau in the field of view and tap the side of your scope. The fainter stars appear to stop moving while Tau keeps bouncing an effect caused by persistence of vision. This peculiar effect gives it the unofficial nickname of the Mexican Jumping Bean Cluster. ☐ **SEEN IT**

GERALD RHEMANN/CDGUIDE COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More ONLINE

Print out this chart and take an automated Go-To tour. See page 5 for instructions.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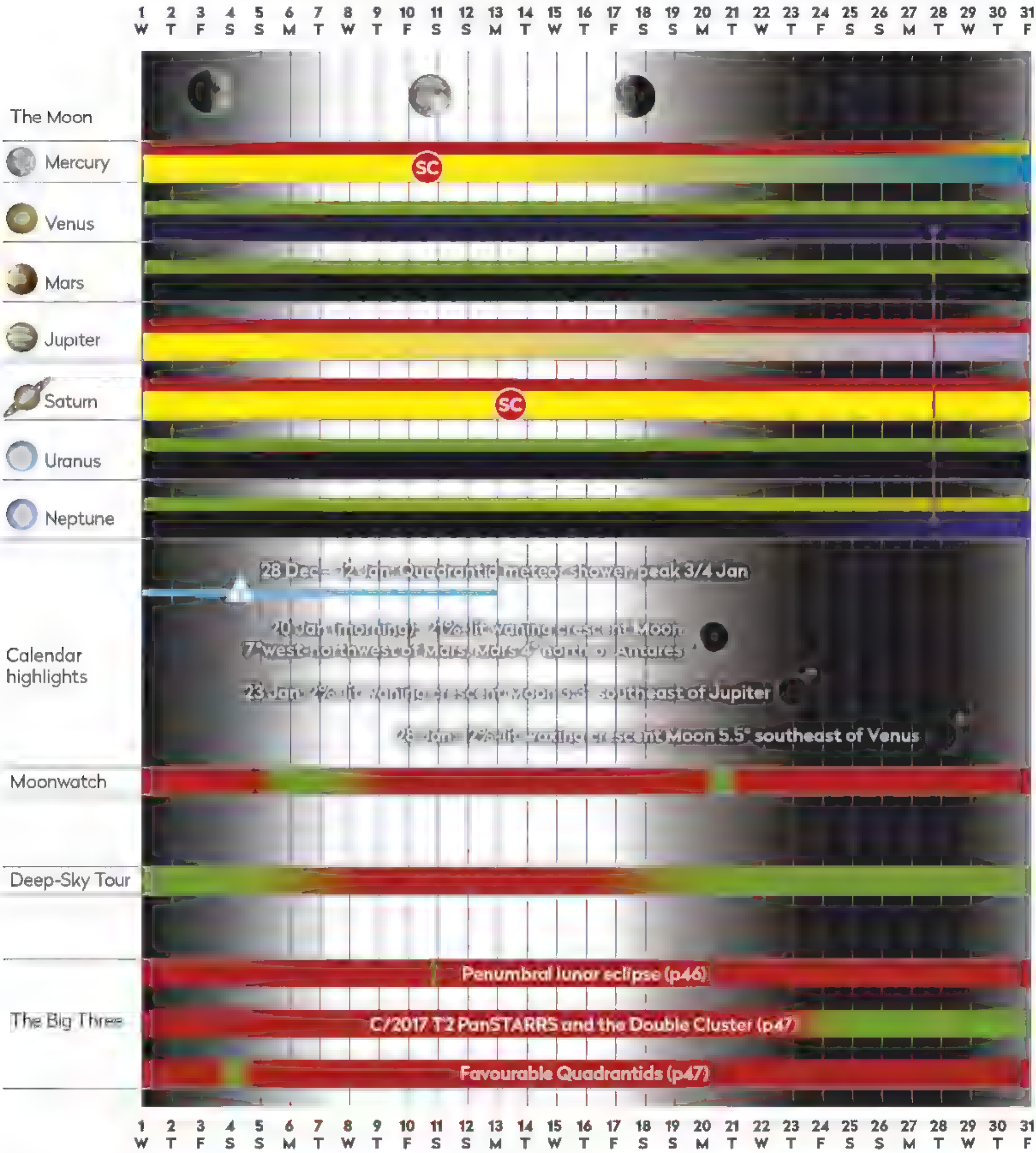
AT A GLANCE

How the Sky Guide events will appear in January



KEY

Observability

Optimal — Poor

Best viewed

Morning twilight — Daytime — Evening twilight — Night

Sky brightness during lunar phases

Dark (first quarter) — Light (full Moon) — Dark (last quarter) — Total darkness (new Moon)

- IC Inferior conjunction (Mercury & Venus only)
- SC Superior conjunction
- OP Planet at opposition
- Meteor radiant peak
- Planets in conjunction
- Full Moon
- First quarter
- Last quarter
- New Moon

CHART BY PETE LAWRENCE

Landmark achievement: Spitzer observed the oldest galaxy ever seen

INFRARED UNIVERSE:

The legacy of the Spitzer Space Telescope

After 16 years of trailblazing infrared observations, this month the Spitzer Space Telescope reaches retirement. **Ben Evans** reports on its astonishing legacy

► **Namesake: physicist Lyman Strong Spitzer conceived the idea of a space telescope in 1946**

Shortly after the Second World War, a young physicist from Yale University published a report outlining the advantages of putting a telescope into space. High above the blurring effect of Earth's atmosphere, he wrote, it could discern the faintest stars and the furthest galaxies with crystalline clarity. His 1946 paper illustrated a growing appreciation for how space travel – still a decade away from becoming reality – could revolutionise astronomy. His name was Lyman Strong Spitzer and in January 2020 a powerful infrared telescope bearing his name will end a remarkable 16-year mission that transformed our understanding of how stars are born and die, how planets evolve and thrive far beyond the Solar System and what lies at the very heart of our Milky Way Galaxy.

Spitzer's name was not simply plucked from a hat, when NASA decided its sparkling new observatory needed a catchier eponym than the unwieldy 'Space Infrared Telescope Facility' (SIRTF) it had borne since its inception two decades earlier. As well as being one of the foremost astronomers of his generation, Spitzer (who died in 1997, aged 82) contributed hugely to studying the interstellar medium, the ubiquitous gas and dust from which new stars form, and his enthusiasm for an Earth-circling astronomical eyepiece eventually won support for the Hubble Space Telescope.

Hubble is one of four 'great observatories' to scrutinise the heavens in unrivalled detail; another, the Compton Gamma Ray Observatory, examined high-energy photons, while a third, the Chandra X-ray Observatory, did likewise for X-rays. The final sibling, SIRTF, was originally earmarked to fly on the Space Shuttle. But the reusable spacecraft's relatively 'dirty' environment – constantly emitting vapours, particles and heat – made it unsuitable for sensitive infrared optics whose *raison d'etre* was detecting thermal radiation. Plans correspondingly changed and SIRTF evolved into an orbiting satellite with high priority in the field of space-based astronomy.

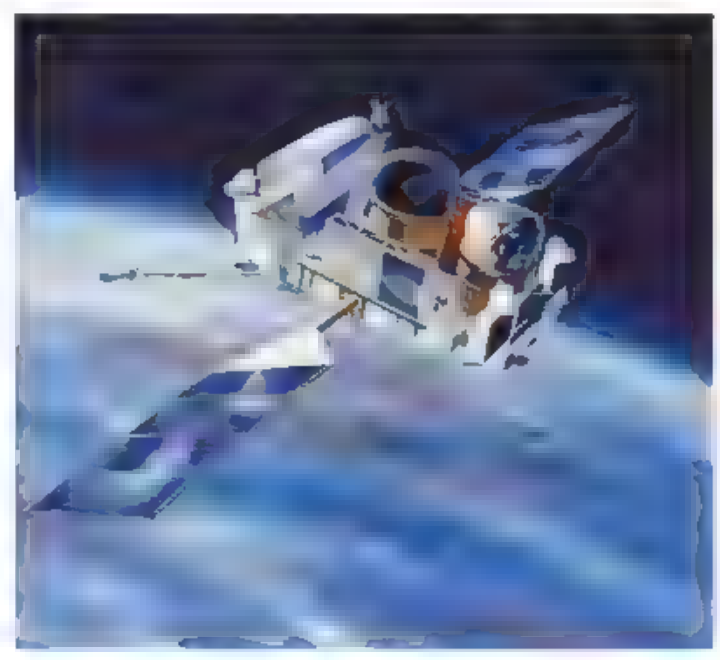
But it was also horrendously expensive. Various scenarios to launch it on Titan, Atlas or Delta rockets threatened to diminish its scientific integrity and its cost hovered around two billion dollars, four times higher than NASA wanted to spend in the fiscally lean years of the 1990s. Then came a breakthrough. By putting SIRTF into an 'Earth-trailing' orbit, it would drift away from us at 14.9 million km every year, ridding itself of the negative thermal effect of our planet on its sensors and winning NASA and prime contractor Ball Aerospace plaudits for saving hundreds of millions of dollars.

Seeing infrared

Infrared astronomy has been practised for two centuries, although it was sparsely explored until recently. Telescopes aboard high-altitude balloons aircraft and sounding rockets could rarely get high enough to make effective observations. But in 1983 the Infrared Astronomical Satellite (IRAS) found 350,000 new objects and peered for the first time into the blazing heart of our Milky Way. The demand for infrared missions quickly gained traction. In the mid-1990s, the Infrared Space Observatory (ISO) detected water vapour in star-forming regions and embryonic planets growing around dying stellar remnants.

More recently, the Herschel Space Telescope shed new light on how stars are born and revealed that much of Earth's water probably originated from ►

▼ **Below (left to right): Hubble, The Compton Gamma Ray and the Chandra X-ray – along with Spitzer, these space telescopes make up the four 'great observatories'**



NASA/JPL-CALTECH, NASA/JPL-CALTECH/T PYLE (IPAC), ESA, NASA, NASA/CXC & J VAUGHAN
DENISE APPLEWHITE/PRINCETON UNIVERSITY/SCIENCE PHOTO LIBRARY

▸ comets; indeed, it demonstrated that Comet Shoemaker–Levy 9 had delivered water into Jupiter's atmosphere. The Wide-field Infrared Survey Explorer (WISE) and AKARI missions also found thousands of new comets, the first near-Earth trojan asteroid and the infrared 'fingerprints' of a supernova, 200,000 lightyears away, deep inside the Small Magellanic Cloud.

Keeping cool

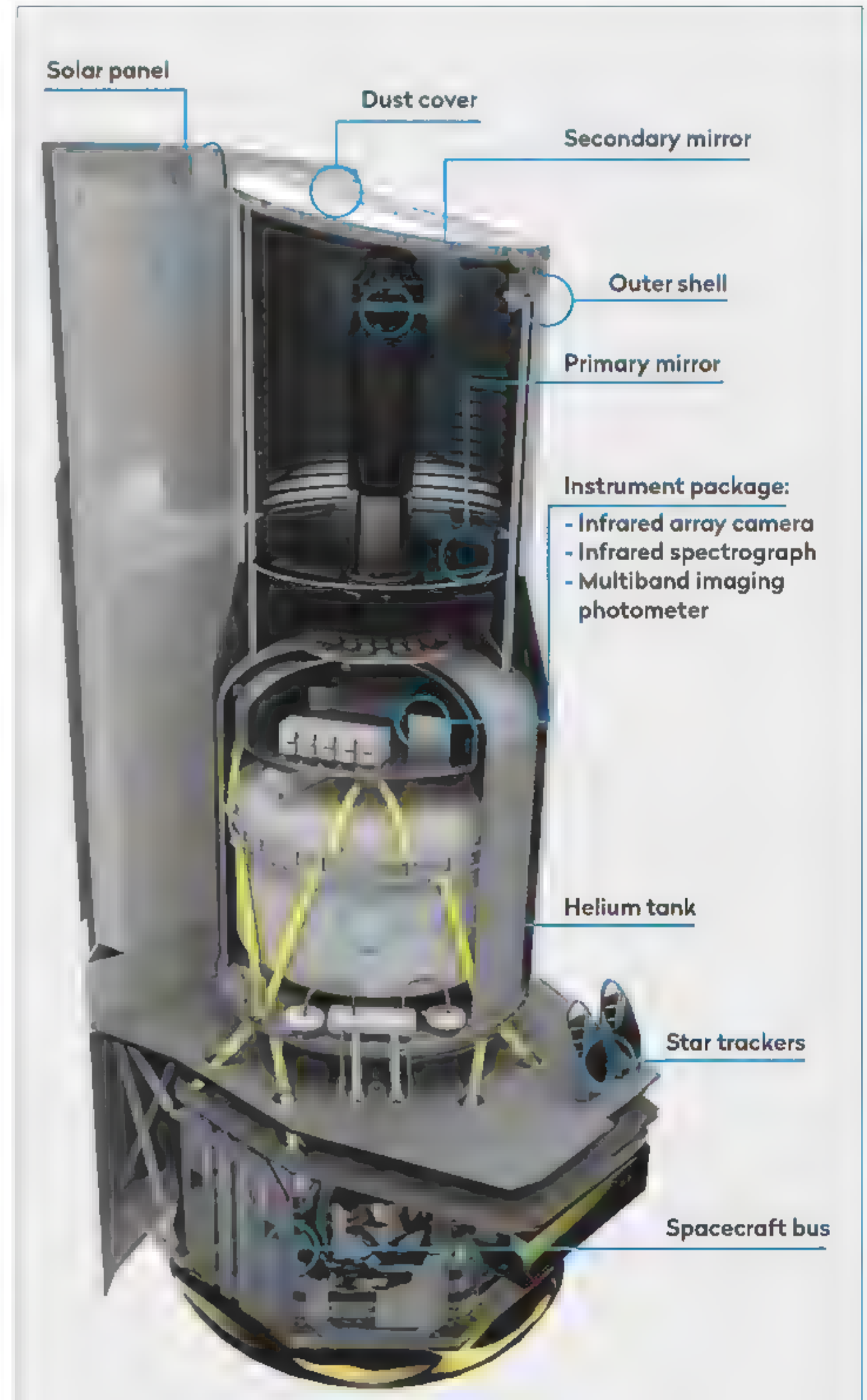
To attain thermal sensitivity in the infrared, telescopes need to cool their optics, lest their measurements become contaminated by radiated heat from Earth or their own electronics. Large cryostats of liquid helium can accomplish this, but when the cryogen runs out the telescope rapidly warms up, its sensitivity to thermal infrared radiation declines and its effectiveness vanishes. Spitzer's Earth-trailing orbit eliminated the problem of our planet's heat and laid the groundwork for another cost-saving revolution: the 'warm-launch' mission architecture.

Rather than encasing the whole spacecraft into a cryostat – and increasing its size, weight and cost to boot – only Spitzer's infrared sensors needed to be chilled before launch. The rest could be built and tested at ambient temperatures. This made it simpler, cheaper and less complex and allowed it to fit a smaller Delta II rocket and carry a smaller cryostat. And when it reached deep space, with no heat-emitting Earth to worry about, Mother Nature (and a built-in sunshade) could passively cool it to –271°C.

The result was that while the Earth-circling IRAS needed 114 gallons of liquid helium to keep cool and lasted 10 months, Spitzer carried 95 gallons but could endure for many years. The clever choice of orbit and warm-launch architecture brought project costs tumbling to $800 million, while parallel technological advances saw infrared sensors evolve from a few dozen pixels per detector on IRAS to 65,000 pixels per detector on Spitzer. Also, the spacecraft was built from lightweight beryllium, which cools rapidly, and a 'store-and-dump' method of data transfer meant it spent less time relaying its findings back home and more time doing scientific research.

Launched from Cape Canaveral on 25 August 2003, the 865kg telescope sailed through initial checks and its three instruments – the Infrared Spectrograph (IRS) and Multiband Imaging Photometer for Spitzer (MIPS), both built by Ball Aerospace, together with NASA's four-channel Infrared Array Camera (IRAC) – came alive.

For the next 16 years, Spitzer improved our comprehension of how stars and planets form, including distant 'extrasolar' worlds. It found newborn

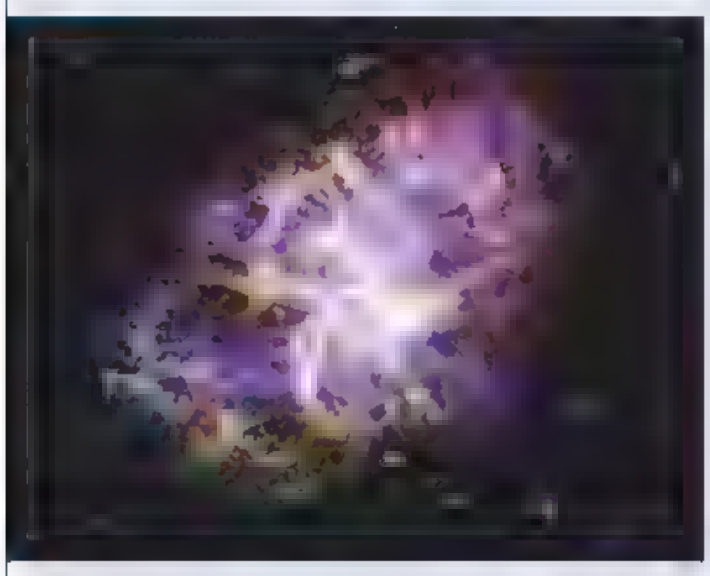


▾ Inside Spitzer: the telescope is a Ritchey-Chrétien reflector, which can operate in temperatures down to –272°C

NASA/KSC, ILLUSTRATION BY PAUL WOOTTON; NASA/ESA; NASA/JPL-CALTECH X 3; NASA/JPL-CALTECH/S. STOLOVY (SPITZER SCIENCE CENTER/CALTECH); ESO/M. KORNMESSER

Mission marvels

Spitzer departs having made some amazing cosmic discoveries and jaw-dropping images

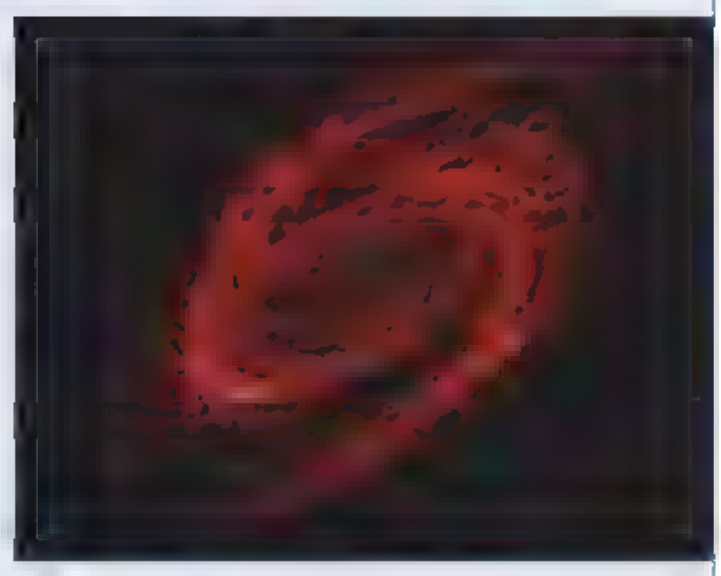


◁ The Crab Nebula

First seen by Chinese astronomers in the 11th century, it's a gaseous supernova remnant with a neutron star at its heart. Ten centuries later Spitzer, working in tandem with Hubble and Chandra, observed this astronomical object that once glowed as brightly as 400 million suns.

Galaxy M81 ▷

Wisps of dust follow the spiral arms of galaxy M81 in this spectacular infrared view. Much of the effect of starlight has been removed in order to emphasise the extent of the dust distribution from the arms into the core of this galaxy, which lies 12 million lightyears from us.

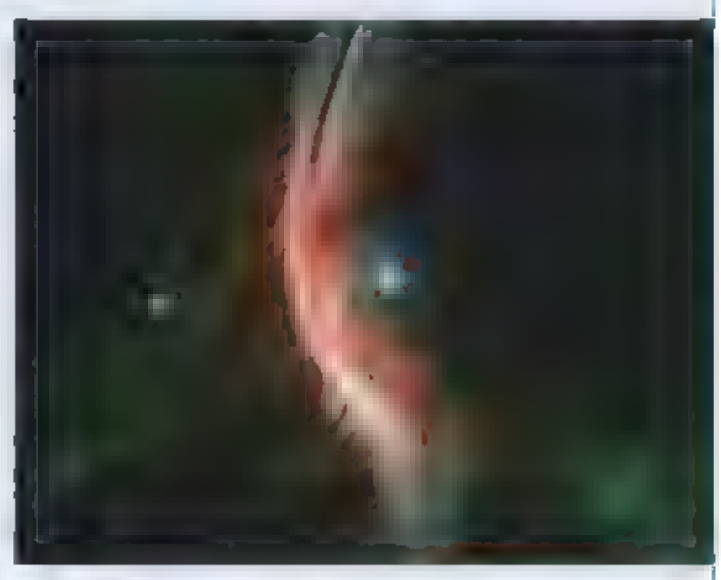


◁ Jack-o'-Lantern Nebula

Like a hollowed out celestial pumpkin, the Jack o' Lantern Nebula features powerful outflows of radiation and particles from a star 15–20 times more massive than our Sun. Its influence swept the surrounding gas and dust away to create strikingly deep gouges.

Zeta Ophiuchi ▷

Massive stellar winds from the giant star Zeta (ζ) Ophiuchi cause ripples in its surroundings to generate a spectacular bow shock. Over 370 lightyears away, it should be one of the brightest stars in Earth's sky, but it is obscured by dust. Spitzer's infrared vision peers through this veil-like shroud.



◁ The heart of the Milky Way

Throngs of ancient stars and luminous clouds of dust lit up by young stars characterise our Milky Way's heart, which glows brightly at infrared wavelengths. Thousands of very short exposures by Spitzer avoided the saturation of its sensors.

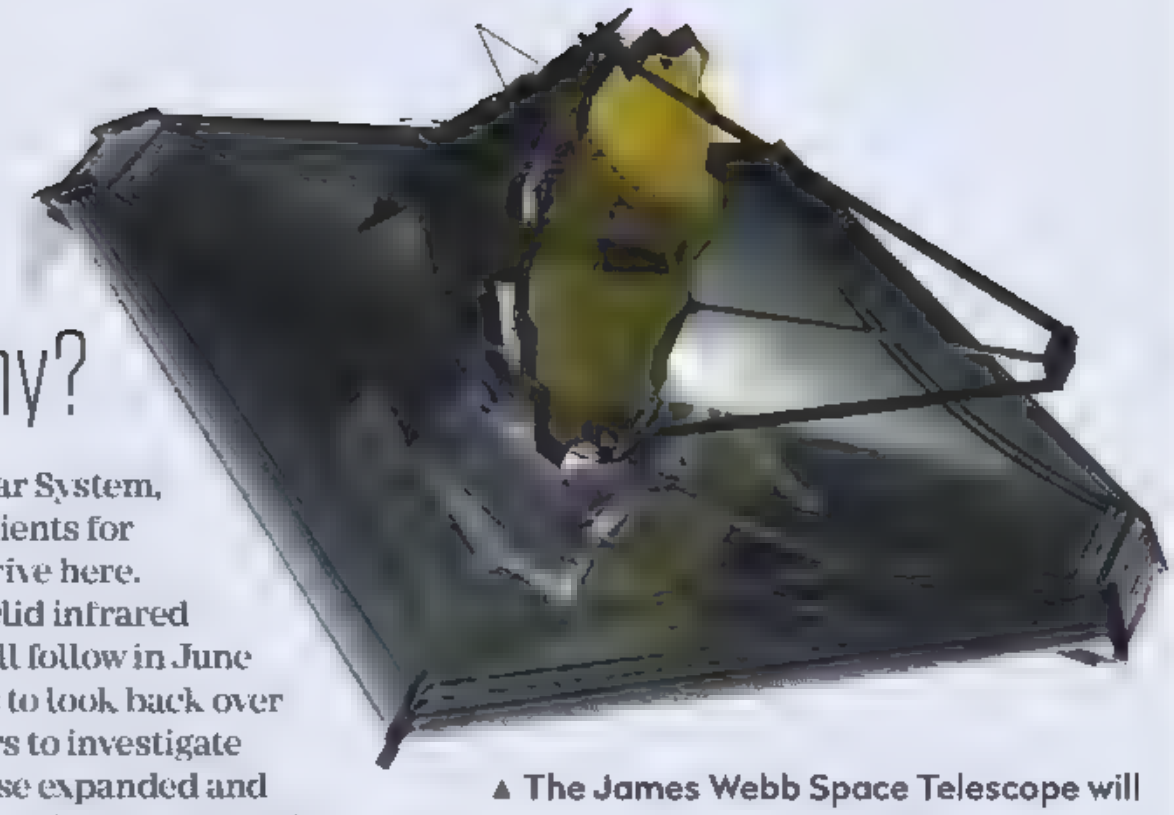
► **Terror planet: HD 189733b, a super violent world discovered by Spitzer with 9,650km/h winds and glass rain**

stars in the Tarantula and Trifid Nebulae, revealed infant stars growing within supernova remnants and showed that even long-dead stars such as Cassiopeia A still punch out periodic bursts of energy. It discovered supermassive black holes hidden in luminous clouds of gas and dust, studied the merger of the Antennae galaxies and under its infrared gaze hundreds of thousands of ancient stars and masses of younger ones blazed furiously at the Milky Way's core.

Old world order

It traced some of the most ancient events since the dawn of creation, with GN-z11 in the constellation Ursa Major now recognised as the oldest and most distant known galaxy in the observable Universe, dating back some 13.4 billion years, not long after the Big Bang. Spitzer found evidence of organics in the form of polycyclic aromatic hydrocarbons billions of years older than our Solar System, as well as partial ingredients for DNA and protein around the star IRS 46. It showed that planets evolve around the most improbable of hosts, including brown dwarfs and hypergiant stars where conditions were previously considered too inhospitable.

And Spitzer underscored precisely how inhospitable these extrasolar worlds are. It directly measured light emitted by the 'hot Jupiters' HD 209458b and TrES-1, revealed surface temperatures of 840°C and roaring 9,650km/h winds on HD 189733b. It showed the tidally-locked planet Upsilon Andromedae b has a thermal differential between its two hemispheres of 1,400°C – a hellish place that one scientist likened to jumping into a volcano. The spacecraft determined that protoplanetary discs can slow their parent star's rotation, found the Sun's close neighbour Epsilon (ε) ►

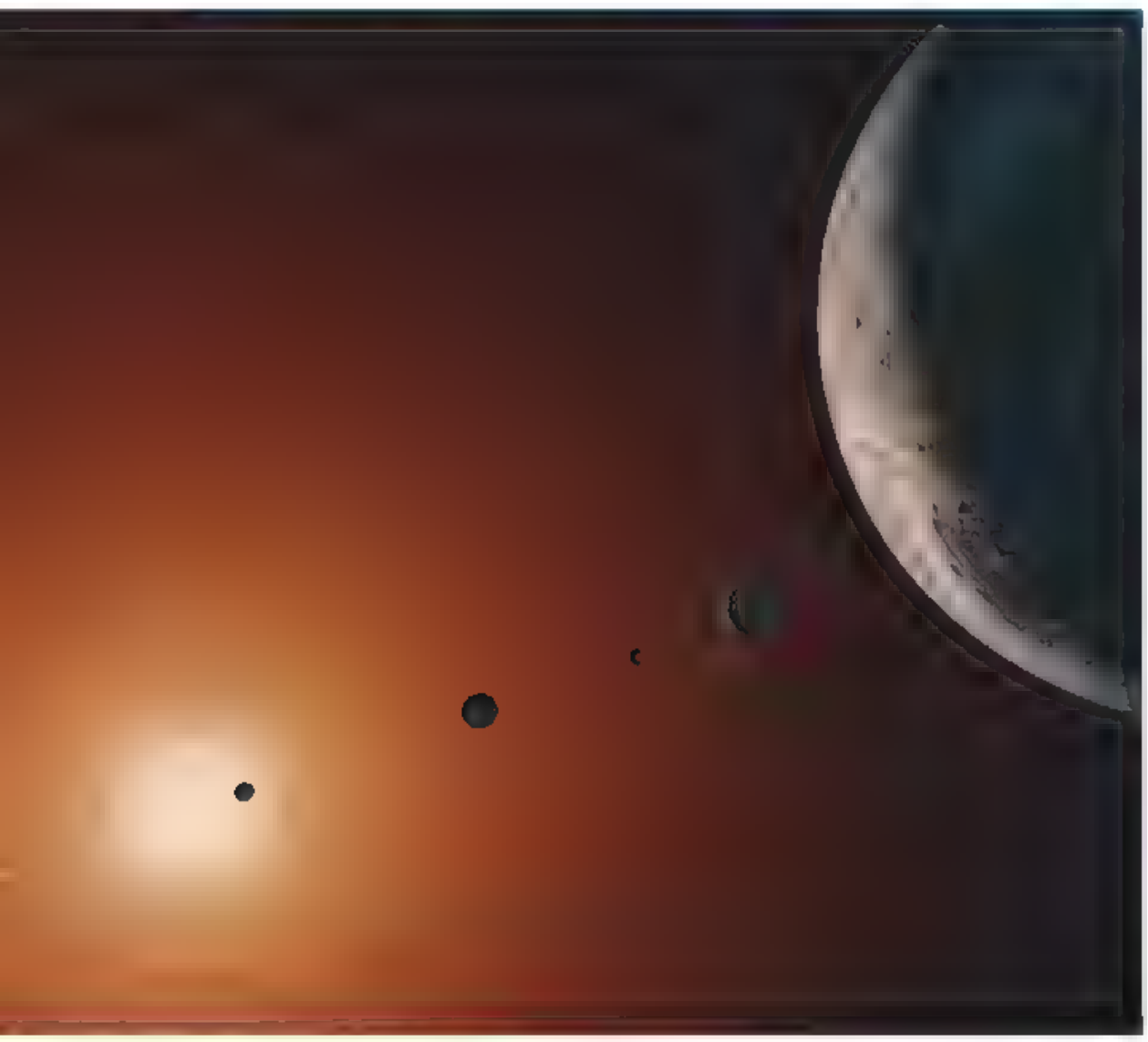


▲ The James Webb Space Telescope will peer back in time over 13.5 billion years

What next for infrared astronomy?

When Spitzer falls silent in January 2020, another year will pass before the infrared baton of discovery passes to NASA's James Webb Space Telescope. It was hoped that Webb's early days in space would happily coincide with the final days of Spitzer, but technical troubles conspired against a neat overlap between them. Webb's launch is currently scheduled for March 2021, and when it does so it will bring four powerful infrared instruments to bear on some of the thorniest problems in astronomy. It will observe the earliest stars and galaxies, study how they and their planetary retinues evolved and, in the case of our Solar System, how the ingredients for life came to arrive here.

Europe's Euclid infrared observatory will follow in June 2022 and seeks to look back over 13.5 billion years to investigate how the Universe expanded and how the first galaxies formed. It will observe billions of astronomical sources with a precision 50 times finer than is presently achievable with ground based instruments. And in the mid 2020s NASA's Wide Field Infrared Survey Telescope (WFIRST) whose fate still rests on a knife edge following efforts by the Trump administration to cancel it will work in tandem with Euclid to tackle basic questions about dark energy in the Universe, as well as taking a census of exoplanets and acquiring the first direct images and spectra of them.



▲ Enter the 'Goldilocks' zone: in 2017 Spitzer observed a batch of Earth-sized planets around the red dwarf TRAPPIST-1

▲ Ring of power: an artist's impression of Saturn's huge Phoebe ring shown in infrared light, which was detected by Spitzer in 2009

raised the likelihood that there are many worlds in the Universe with two suns, just like Luke Skywalker's *Star Wars* home, Tatooine.

End of the line

In May 2009, Spitzer's coolant ran out and temperatures rose to –242°C: still chilly, but not chilly enough for IRS and MIPS to function. Still, the two short-wavelength channels of IRAC remained active and NASA recalibrated the spacecraft for an extended 'warm' mission. For another decade, the flood of discoveries continued: finding Saturn's tenuous Phoebe ring, scrutinising the rocky exoplanet HD 219134b, discovering the trans-Neptunian object Sedna and observing Earth-sized worlds in the habitable 'Goldilocks' zone around the cool red dwarf TRAPPIST-1.

But as its orbit carried it further from Earth – more than 257 million km away as 2019 ended – the ageing Spitzer had to pitch at higher angles to transmit data with a corresponding reduction in the amount of incident sunlight on its solar panels. On 30 January 2020, when its mission ends, the Spitzer team can reflect with pride on a spacecraft that tripled its predicted lifetime and infinitely exceeded all expectations. And like Lyman Strong Spitzer himself, whose extraordinary life ended after an ordinary day at work, so his mechanised namesake will take its place in history with grace and dignity.

Ben Evans is the author of several books on the history of spaceflight

NORTHROP GRUMMAN, NASA/JPL-CALTECH/T. PYLE (IPAC) X 2

COMING SOON...

DISCOVER THE MOON

BBC Sky at Night MAGAZINE

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02–09 MARCH

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Two centuries of DISCOVERY:

The Royal Astronomical Society turns 200

On its 200th anniversary, **Katrin Raynor-Evans** looks at the past, present and future of the learned institution

The date is 6 November 1919, and in a packed room in the heart of London, astronomers and scientists have assembled to hear the results of an eclipse expedition organised by famed astronomer Arthur Eddington and Astronomer Royal Frank Watson Dyson. Earlier that year, Eddington had travelled to the African island of Príncipe to study the total solar eclipse of May 1919, in the hope of testing Einstein's theory of general relativity. If everything has gone to plan, Eddington and his team will have witnessed a bending of starlight during the eclipse, proving Einstein's theory. Dyson takes to the stage, announcing above a murmur of hushed anticipation, "there can be no doubt" that the expedition was a success: Einstein's theory has been proven correct. The building they are in is Burlington House, now home of the Royal Astronomical Society (RAS), and the event will go down in history as just one of many astronomical discoveries announced within its four walls.

Changing times: a meeting of the RAS in 1936 at Burlington House is mainly attended by men.

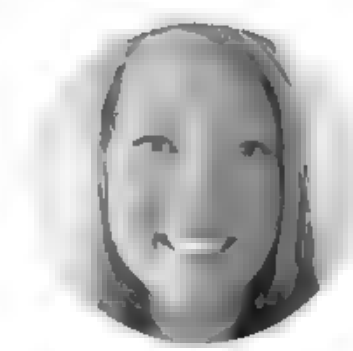
ROYAL ASTRONOMICAL SOCIETY/SCIENCE PHOTO LIBRARY, STERNWARTE WEINHEIM/ALAMY STOCK PHOTO

Rising stars

The RAS came into being exactly 200 years ago this month, when 14 gentlemen astronomers met for dinner on 12 January 1820 in London at the Freemason's Tavern in Lincoln's Inn Fields. There, they formed the Astronomical Society of London, which would eventually grow into the 4,000 member-strong RAS we know today. Now, as then, its motto is 'Quicquid nitet notandum' – 'whatever shines should be observed'.

Based in Burlington House, once a private mansion in a courtyard in London's Piccadilly, the Society shares a home with other learned societies such as the Geological Society, the Royal Society of Chemistry and the Royal Academy of Arts. Its library houses thousands of specialist books, photographs archives and manuscripts dating back to the 15th century. Original works by Copernicus, Schwabe and Cassini – even a piece of apple tree said to derive from Newton's garden – can all be found in the Society's library.

Members meet regularly at Burlington House to hear and discuss current research in astronomy among peers and the public. There's also a five-day UK event organised and funded by the Society every year, the National Astronomy Meeting, which is usually held in spring or summer and attracts around ▸



Katrin Raynor-Evans is an astronomy writer and a Fellow of the Royal Astronomical Society

Steeped in history: the Royal Astronomical Society's entrance at London's Burlington House, the home of the Society since 1874

Eminent Fellows

The Royal Astronomical Society has counted some big names among its members over the past 200 years

Sir William Herschel (1738-1822)

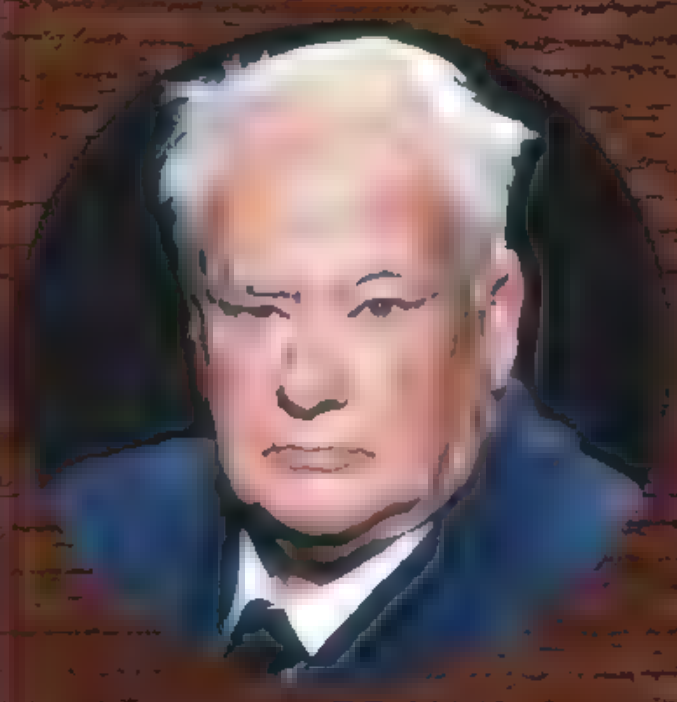
First President of the Society who discovered Uranus in 1781. His Great 40-foot telescope, which was used to discover the moons of Saturn forms the Society's crest.

Francis Baily (1774-1844)

President of the Society four times. Famous for his research on Baily's Beads, arcs of bright spots observed during an eclipse. He first described these during an annular eclipse of 1836.

Annie Scott Dill Maunder (1868-1947)

One of the first women to be elected as a Fellow in 1916. She worked at the Royal Observatory Greenwich on observational data and photographed the Sun's atmosphere during an eclipse.



Sir Patrick Moore (1923-2012)

Amateur astronomer and presenter of *The Sky at Night*. Moore wrote the *Caldwell Catalogue*, a list of star clusters, galaxies and nebulae that complements the *Messier Catalogue*.

Dame Jocelyn Bell Burnell (b.1943)

President of the Society from 2002-04. The astrophysicist co-discovered the first radio pulsars in 1967 and received a Nobel Prize in 1974 for her groundbreaking work.

Professor Bernard Schutz (b.1946)

Winner of the 2019 Eddington Medal for research in gravitational waves. He is one of the founding members of the Max Planck Institute for Gravitational Physics located in Germany.

CHRONICLE/ALAMY STOCK PHOTO; AXIS IMAGES/ALAMY STOCK PHOTO; BBC., GERAINT LEWIS/ALAMY STOCK PHOTO; CAMBRIDGE UNIVERSITY SCIENCE HISTORY IMAGES/ALAMY STOCK PHOTO; ROYAL ASTRONOMICAL SOCIETY/SCIENCE PHOTO LIBRARY; JOHANNES SCHEDLER/CCDGUIDE.COM. © 2019 ROYAL ASTRONOMICAL SOCIETY/PHOTOGRAPHY BY LYNDA LAIRD

▸ 600 attendees for talks, discussions and public lectures on the latest astronomical research.

Throughout the year, the RAS hosts an array of committees that oversee its membership, award outstanding contributions to astronomy and promote education and outreach, all directed and managed by its council. Mike Cruise, the current president, is professor of astrophysics and space research at Birmingham University and a researcher of gravitational waves and general relativity.

Yet while it is now considered one of the most eminent societies in the world, encouraging and promoting astronomy, cosmology, Solar System science and geophysics to all, the RAS wasn't always as open. Like most revered societies of the time, from its inception membership of the RAS was solely limited to men, and little thought was given to the fact that women would want to join the Society. This was partly down to the traditional expectations of women at the time with regard to the pursuit of science, and it was not helped by the fact that membership rules simply referred to 'he' and 'him'.

Gaining recognition

But this exclusion did not stop the society recognising female astronomers and the work that they achieved. Caroline Herschel was awarded the Gold Medal in 1828 for her groundbreaking work on nebulae. Housekeeper to her brother, the famous astronomer William Herschel, Caroline also

▲ **Pioneering: Caroline Herschel discovered Messier 110 (right) and was the first woman to win the Society's Gold Medal (inset) in 1828**

contributed to the famous family's astronomical work. In 1783 she discovered three nebulae, including Messier 110, and was the first woman to discover a comet, 35P/Herschel-Rigollet, in 1788.

In 1835, honorary membership was bestowed to women before, finally, the acceptance of women as RAS Fellows came in 1916. Today, the group welcomes astronomers from all walks of life and encourages applications for membership irrespective of race, gender, disability, religion or sexuality.

Caroline Herschel's brother William was an accomplished astronomer and composer, and became the first President of the RAS after it was founded, a post since held by a long list of distinguished astronomers including former Astronomer Royal Sir George Airy, who was first elected President in 1835, and Sir Bernard Lovell, who founded Jodrell Bank Observatory and was RAS President from 1969-71. There have been only three female Presidents, the first being Dame Carole Jordan, who was elected in 1994 and is a world authority on stellar and solar physics. Since then, Professor Jocelyn Bell Burnell, co-discoverer of neutron stars, and geophysicist Professor Kathryn Whaler have taken up the post, in 2002 and 2004 respectively.

Beyond its role disseminating information, the RAS also rewards achievements in astronomy and geophysics. Medals are awarded for an array of subjects including theoretical astrophysics, solar terrestrial physics and education. The highest award given is the Gold Medal in astronomy and geophysics, and it has been bestowed on a number of illustrious scientists since the 1800s. It was first presented in 1824 to Charles Babbage for his mechanical computer, which was used to calculate mathematical and astronomical tables, and also to Johann Franz Encke for his calculations and prediction in the return of Comet Encke. Other recipients include Albert Einstein; theoretical physicist Ejnar Hertzsprung, co-creator of the Hertzsprung-Russell diagram; cosmologist Edwin Hubble; radio astronomer Jan Oort and the late Professor Stephen Hawking.

After Caroline Herschel became the first female winner of the prize in 1828 for her work in observing and cataloguing nebulae, it would be 168 years before another woman would win the Gold Medal, when Vera Rubin was awarded it for her pioneering research on the rotation of galaxies, which provided some of the earliest evidence for dark matter.

▼ **Latest in line: RAS President Mike Cruise (left) presents the Gold Medal to Professor Robert Kennicutt in 2019**

Meeting today's challenges

The most recent recipient of the Gold Medal was US astronomer Professor Robert Kennicutt, who received the Gold Medal in recognition of his research on star formation in galaxies. "I got the news via email shortly after New Year's, and I was utterly stunned and moved by it, actually disbelieving at first," says Prof Kennicutt, formerly of the University of Cambridge but now an astronomer at the University of Arizona. "To join such a distinguished list of previous winners is an honour beyond description." ▸

TIMELINE
200 years of the RAS

1820 – The Astronomical Society of London is formed

1824 – Charles Babbage and Johann Encke receive the first Gold Medal

1827 – *Monthly Notices*, the RAS's newsletter, is first published

1831 – Royal charter signed by William IV

1916 – Women are accepted as Fellows

1919 – Einstein's theory of general relativity is tested, and the results are presented at a joint meeting with the Royal Society

1948 – The first 'out of town' meeting is held in Edinburgh

1970 – The Royal Mail celebrates the 150th anniversary with a commemorative stamp

1974 – The first female President, Carole Jordan, is elected

2020 – The bicentenary of the RAS

An outreach and engagement project, RAS 200: Sky & Earth, is providing £1 million to support 12 outreach projects

▸ To mark this year's 200th anniversary, an outreach and engagement project, RAS 200: Sky & Earth, is providing £1 million to support 12 outreach projects to promote astronomy in communities across the UK.

"The aim in supporting the winning projects is to build lasting astronomical legacies within local communities, with the help of Fellows local to the area," says Professor Steve Miller, chair of the steering group for RAS 200. "The projects range from space sleepovers for the Brownies and Guides at the National Space Centre in Leicester, to projects involving prisoners and their families, as well as young people who have had a difficult start in life.

"RAS 200 has a strong regional flavour, too, with projects in east Scotland, west Ireland, northeast England, Wales and Cornwall, as well as South Africa. This is investment for now and the future: it will leave a legacy of really embedding the RAS in the hearts and minds of our fellow citizens for years to come."

In July 2019, I took part in an RAS 200 event at the Prince's Trust at their Cardiff centre, spending the day with young people aged between 18-25 participating in fun educational bite-size astronomy projects. Steve Wells who works for the Prince's Trust and organised the event, says: "A group of young people attended the session on stargazing planets and the size of the Universe. The activities were great for exploring what they already knew and great for their confidence and their presenting skills." Feedback was also positive. "The session gave me a renewed interest in space, which I haven't had for a while," said one participant. "It was fun and informative and the backstories behind the constellations were interesting," said another.

The RAS has come a long way since its inaugural meeting at a candle-lit tavern two centuries ago. And, by staying focused on how astronomy can inspire and motivate people, recognising incredible achievements and encouraging the study of astronomy and geophysics, the Society has a bright exciting future ahead.

Follow the Royal Astronomical Society:

Online: www.ras.ac.uk

On social media: @RoyalAstroSoc

On YouTube: www.youtube.com/user/RoyalAstroSoc

ROYAL ASTRONOMICAL SOCIETY X 2, SUSIE KEARLEY/ALAMY STOCK PHOTO

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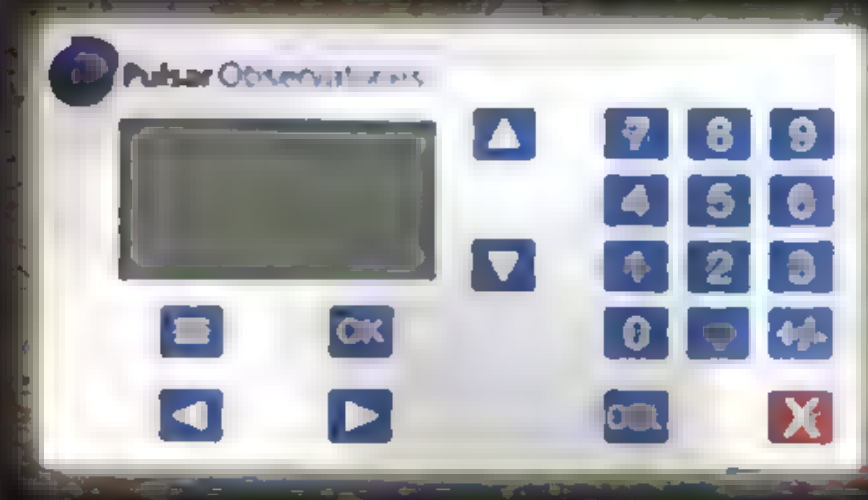

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The fundamentals of astronomy for beginners

EXPLAINER

New tech for KEEPING WARM

Wrap up warm for winter stargazing adventures with **Siân Anna Lewis**'s pick of the new fabric and materials that will keep you cosy even on the coldest of clear nights

◁ BAM bamboo zip-neck base layers

Have you ever heard of the 'onion method'? The best way to stay warm in cold conditions is to layer up your clothing, allium-style, in order to trap in your body heat. If you're using this method to stay warm on a cold stargazing trip, make sure you start off with a thermal base layer worn next to the skin before you pop a down jacket and a warm waterproof coat on top. We love BAM's bamboo base layers, especially their soft and comfortable zip-necked long-sleeved top for men and women. Bamboo is a bit of a wonder fabric – as well as being a sustainable material, it's naturally warm and moisture-wicking, keeping you cosy if you're at a standstill and cool when you're moving.
Price: **£44–£48** • Website: **https://bambooclothing.co.uk**

Picture Earthen base layer ▷

Meet the magical disappearing base layer. The Earthen is a smart and high-performing base layer top, made of delightfully soft, moisture-wicking wool. And it also has an eco-friendly trick up its sleeve - the Earthen top is fully biodegradable once it's in landfill. But don't worry, it won't disintegrate when you're still wearing it – the base layer requires the specific oxygen-free environment of landfill to degrade. As well as being a cosy layer that feels great worn next to the skin on stargazing evenings, the Earthen also looks smart enough to wear as a day-to-day top with jeans. Win-win.
Price: **£77.99** • Website: **www.snowleader.co.uk**

◁ Berghaus Tephra Stretch Reflect down jacket

The cosy-as-anything Tephra Stretch jacket is stuffed with Berghaus's innovative water-resistant Hydrodown insulation. Unlike other down, Hydrodown takes light rain or snow in its stride. Available in men and women's styles, the Tephra Stretch is padded but not bulky, with stretchy fleece side panels that make it flexible, slim-fitting and easy to move in. If you feel the chill, Berghaus' Reflect technology in the jacket's mesh lining works to keep body heat trapped inside for that extra warmth at night-time.
Price: **£136-170** • Website: **www.berghaus.com**

◁ Montane Prism insulated trousers

Who knew you could buy a down jacket for your legs? Just pull on Montane's insulated Prism trousers to feel instant warmth on the coldest nights. Despite being lined with plenty of PrimaLoft Silver Eco warm insulation, the Prism trousers are still slim and pack down small, easily fitting in a rucksack. The ripstop outer fabric cuts wind chill and is water resistant enough to withstand light rain. The trousers are designed for men but the unisex fit works well for women, too
Price: **£125** • Website: **www.montane.co.uk**

△ Rohan Husavik jacket

The Husavik's light weight and slim cut belies how warm this seriously insulated jacket is – it may look like a sleek parka, but it performs like a thick down puffa jacket. The three-layer Barricade technology and longer, thigh-skimming cut keeps the wind and cold at bay. The Husavik, available for men and women, is far more packable than a bulky down jacket, and looks smart, too – this could double up as your winter coat for city wear when you aren't stargazing. The Husavik is on the pricy side, but if you're serious about getting out and stargazing all winter long, we think it's a sound investment.
Price: **£395** • Website: **www.rohan.co.uk**

Danner Arctic 600 boots ▷

Warm, rugged and waterproof, Danner's Arctic 600 might be a perfect winter boot. The 600s will keep your toes toasty even in freezing damp conditions due to their magic combination of heat-retaining PrimaLoft insulation and Danner's own-brand Danner Dry technology which repels water and slushy snow. But where these boots excel is when you're walking on slippery ice – their Arctic Grip soles offer amazing stay-put traction. The boots are easy to pop on and off, thanks to the side zips. Handsome suede looks means they can be worn anywhere from mountain peaks to the pub.
Price: **£180** • Website: **https://global.danner.com**

Siân Anna Lewis is a travel and outdoor adventure journalist who has written for *The Independent*, *BBC Countryfile Magazine* and *Lonely Planet*. She is editor of thegirloutdoors.co.uk

Practical astronomy projects for every level of expertise

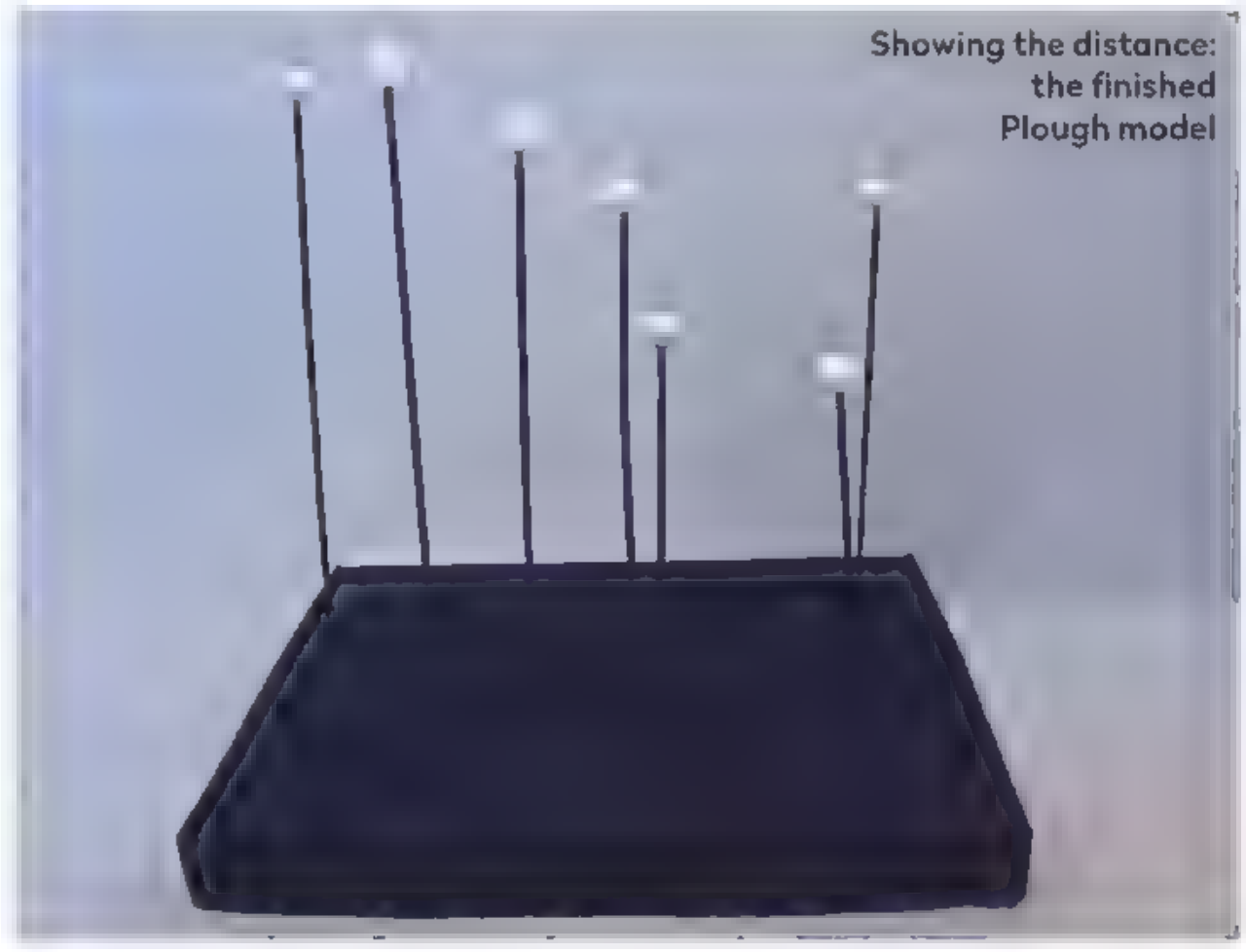
DIY ASTRONOMY

FAMILY FRIENDLY PROJECT

Make a model of the Plough

Discover how our line of sight makes a familiar star constellation take shape

There is a common misconception that stars within constellations and asterisms are gravitationally bound and exist close to each other. In fact, most constellations contain stars that are at vast distances away from each other and the grouping we see is just a line of sight effect. It can be difficult to explain this, so to help people visualise it you can make a model of a constellation or asterism. For our model, we used the seven-star asterism, the Plough, but the technique can be adapted for any star grouping as long as the distances of the stars as seen from Earth are not too separated.



Showing the distance: the finished Plough model

Shifting positions

Our ancient ancestors thought that the stars were all the same distance from Earth, rotating on a celestial sphere made of crystalline aether. We now know this is not the case, and the distances of stars we can see with the naked eye can vary hugely so we have to be careful as to which stars or constellation we use for our model. The nearest bright star to Earth after the Sun is Alpha Centauri, 4.3 lightyears away, although technically it's smaller companion Proxima Centauri is closer at 4.2 lightyears. The most distant star visible to the naked eye is known as V762 Cas, a mag. +5.87 star in Cassiopeia estimated to be 14,825 lightyears away. Accurately calculating the distance of stars is difficult and more recent data from 2007 suggests that V762 Cas is only 2,764 lightyears away. The distances between these stars is huge; so big that it would be difficult to build a scale model of a sensible size. So, you can see why we will stay with using the Plough where the stars are at a range of 78 to 124 lightyears away. Most of the main stars of the Plough, except Dubhe (Alpha (α) Ursae Majoris) and Alkaid (Eta (ε) Ursae Majoris), are part of the Ursa Major Moving Group, so their positions over time change due to the cluster moving through space. We are lucky to live in an era when we see them together as the Plough.

Mary McIntyre is an astronomer and dedicated astro imager based in Oxfordshire

For our model, the stars were each assigned a number for ease of reference, going from left to right as you look at the asterism. The distance from Earth for each of those stars are listed in our downloadable table (see below). Importantly, the distance of these stars vary by just under 50 lightyears. A full-sized print out of the Plough was used for the other measurements.

Our model was created with the stars placed so that their distances are proportional to their distance from Earth. When viewed from the front they create the shape we all know. When viewed from another angle, the stars no longer look like the familiar shape which shows the constellations are a line of sight effect.

Tools and materials

- Seven wooden barbecue skewers, at least 40cm long
- Seven small, white polystyrene balls, approximately 20mm diameter
- A shallow box measuring at least 40x25cm front to back and 4cm tall. This box allows for easy storage of the model in between use
- A full sized printout of the Plough. We used a screenshot from Stellarium and printed it, so it almost filled a piece of A3 paper
- Black paint for painting the box and skewers

ALL PICTURES MARY MCINTYRE

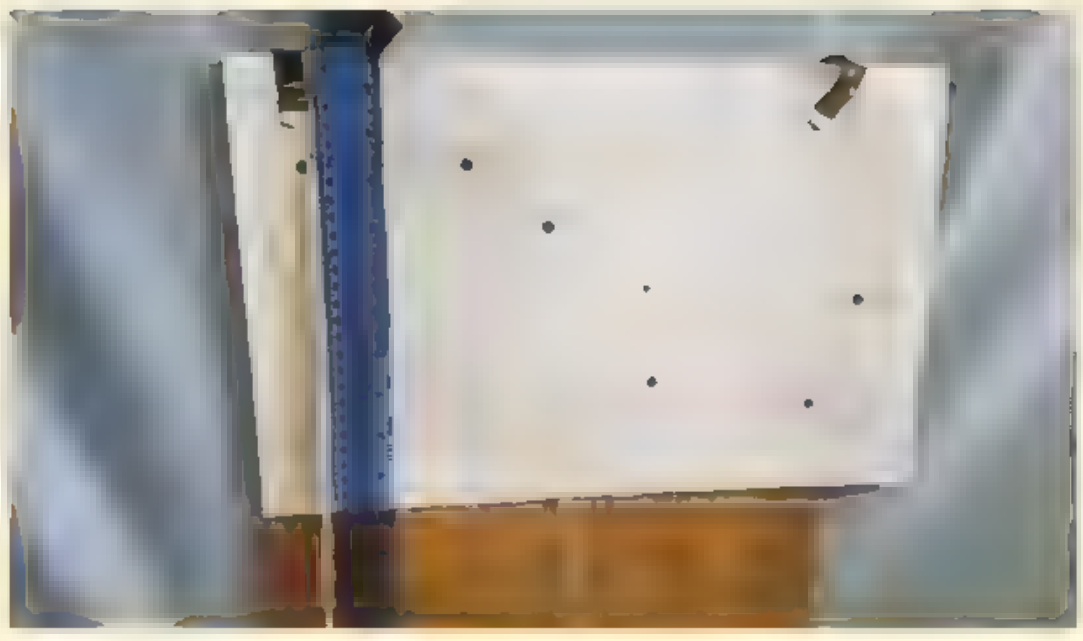
More ONLINE

Download a table of star distances and measurements for the Plough. See page 5 for instructions

Step by step

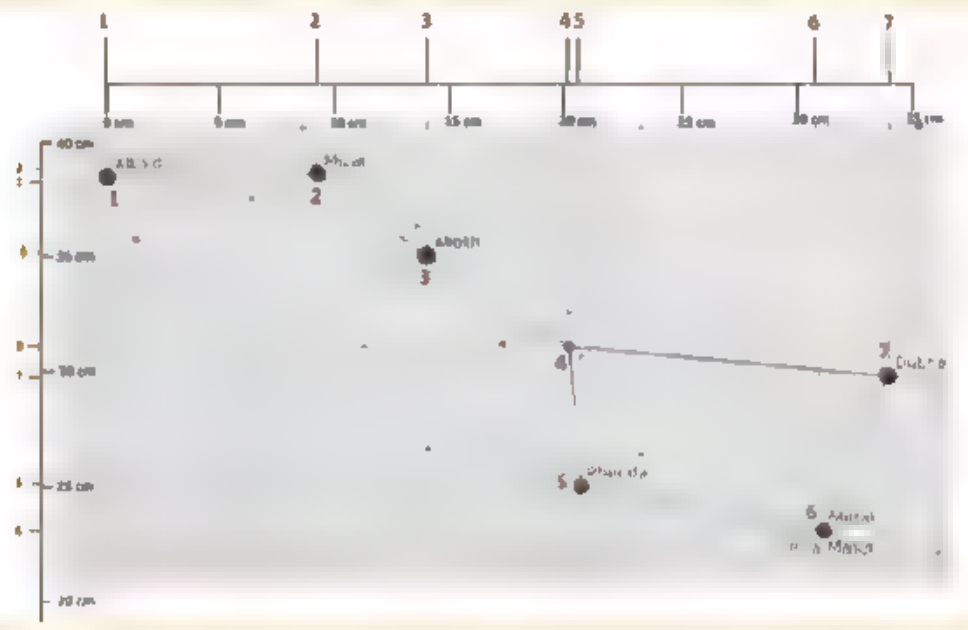
Step 1

Paint the barbecue skewers black so they can't be seen when the lights are turned out. Then poke them into the polystyrene balls, using a bit of PVA glue to secure them firmly in place. The balls represent the stars.



Step 2

Using the full sized print out of the Plough, hold the paper a suitable distance above the box and measure the height of each star to represent the vertical extent of the star positions. This gives us the familiar 'shape' of the Plough we see in the sky.

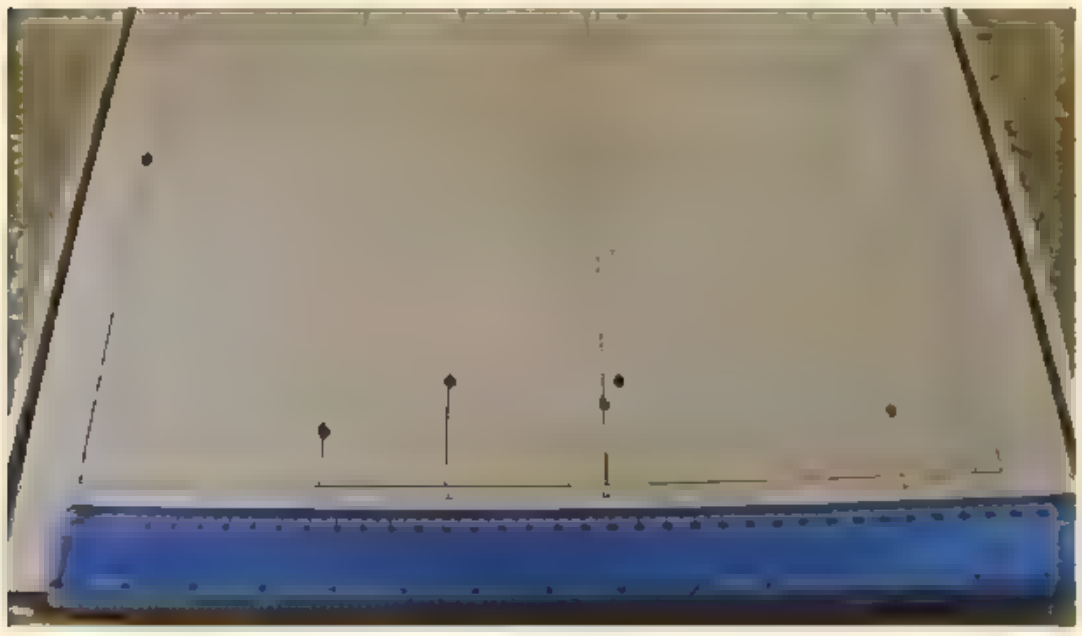


Step 3

Cut the sticks to the correct length using the height measurements from Step 2. Label each stick as you go otherwise it would be easy to mix them up and get the wrong positions for the stars. You don't want to accidently distort the Plough's shape.

Step 4

Also using the full sized print out of the stars, measure the positions of the stars from left to right. The photo shows how the measurements were taken and marked on the print out. Exact measurements are in a downloadable table (see page 5).



Step 5

Draw a rectangle, 35x25cm, on the box's top. Calculate the distances of each star, allowing 1cm for 2 lightyears. Assume the front of the rectangle begins at 75 lightyears and ends at 125 lightyears. Mark where each skewer will go and make a hole.

Step 6

Paint the box black and label each hole so it is easy to put the model together. Poke the skewers into the holes, using a blob of Blu Tack under each hole to secure them. To keep things in scale, make sure the model is viewed from 37.5cm away.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Imaging a penumbral lunar eclipse

Capture the subtle darkening of the Moon's surface by combining views from different times

▲ **A layered image of a penumbral lunar eclipse can emphasise the darkening of the penumbra shadow**

AL PICTURES PETE LAWRENCE

The Moon undergoes a penumbral lunar eclipse on 10 January. The event starts at 17:08 UT and ends at 21:12 UT, the point of greatest eclipse occurring at 19:10 UT. As lunar eclipses go, penumbral ones are the hardest to both see and photograph due to the weak nature of Earth's outer penumbral shadow. Rather than showing the dark, well-defined edge of an umbral lunar eclipse the penumbra presents itself as a gradual shading across the Moon's face with no discernible outer edge. If you didn't know it was happening, you could look at the Moon mid-eclipse and be none the wiser.

The best way to secure a positive observation of the 10 January eclipse is to use a camera. It'll be the southern portion of the Moon's disc that moves deepest into the penumbra and it's here that the shadow will appear darkest. The effect we need to reveal is how much this portion of the Moon's disc appears to darken due to it being inside the penumbral shadow.

The easiest way to do this is to take one image before or after the eclipse and one at the point of greatest immersion. As the Moon will appear higher in the sky towards the end of the eclipse this is the best time to capture the 'control' (uneclipsed) image, a result which will reveal how the full Moon looks normally with no effects from any part of Earth's shadow.

Taking the shots correctly exposed is made harder by the Moon's change in altitude, together with any variation in the transparency in the sky. It's possible to apply a degree of calibration to the shot by getting the northern portion of the Moon's disc – the part which is least affected by the penumbral shadow – to look the same in both the eclipsed and control image. Once you've managed this, the darkening of the cratered southern region will be evident when eclipsed.

As the Moon is a bright astronomical object, it's well suited for DSLR imaging. A low ISO is recommended to maintain a good tonal balance and to keep noise at bay. Even with such a setting it should be possible to maintain a short exposure time, which means you don't absolutely need equatorial tracking. A lens on a tripod will work just as well here. However, equatorial tracking will make it easier to keep the Moon in frame.

This task is suitable for all camera-lens combinations as long as the lens is capable of showing the Moon as a disc with recognisable features. A DSLR attached to a scope with around 1m of focal length is ideal, but a setup that has the Moon's disc almost filling the short dimension of the camera frame will require tracking.

The rest is down to presentation. In our step by step guide, we take you through the basic requirements for capture with a suggestion of how to present your results to best effect once obtained.

▸ **See page 46 for more information about the eclipse**

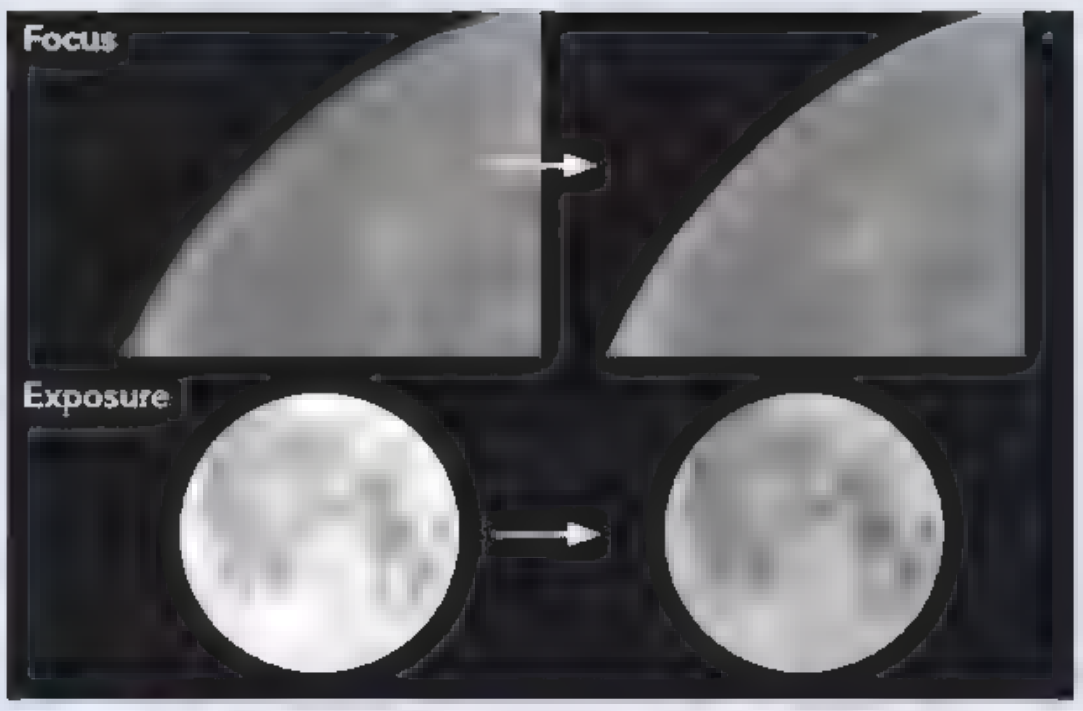
Recommended equipment: DSLR camera; a 200mm or longer focal length lens or telescope

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

Send your images to:
gallery@skyatnightmagazine.com

STEP 1

Choose which lens or scope you intend to use. A longer focal length gives a larger image scale. We'd recommend a minimum 200mm lens to show the Moon's disc together with the region most affected by the eclipse shadow. A 1m focal length will give close up detail, but anything longer will need tracking to keep the Moon in frame.



STEP 2

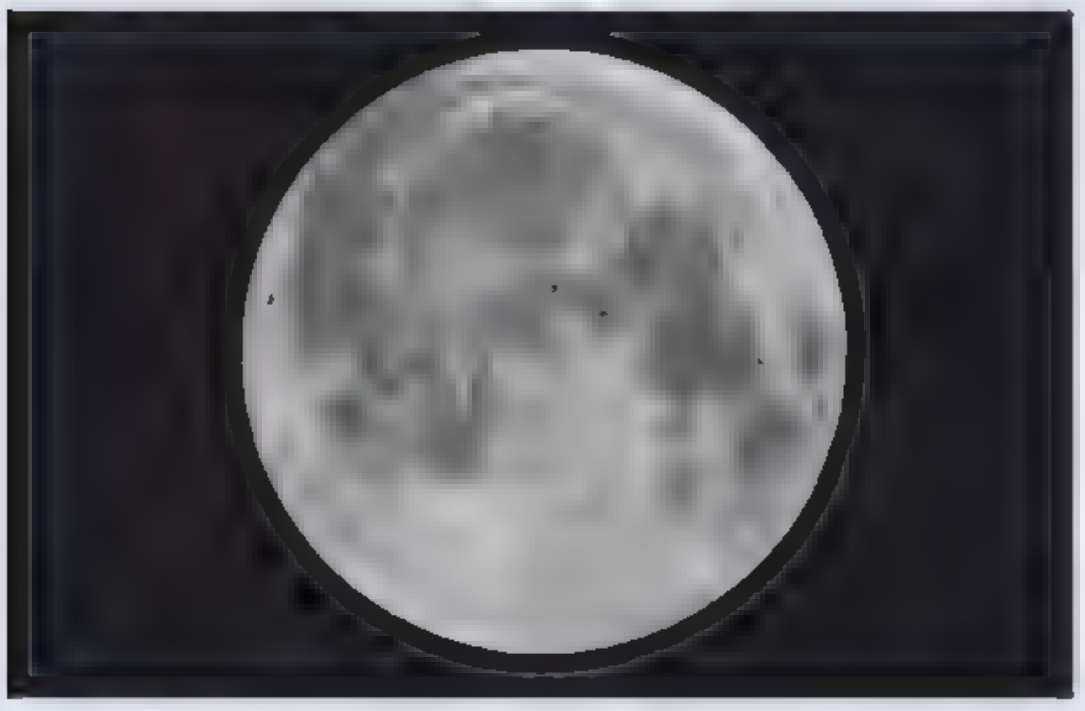
Focus is critical for the best results so take your time. If your camera has Live View use that, magnifying the Moon's edge. Set a lowish ISO, 100 200. If using a lens, stop the aperture down to f 8 11. Adjust exposure time accordingly. Ensure that your images don't have regions that over expose. If so, shorten the exposure time.

STEP 3

Moonrise on 10 January is around 16:00 UT as seen from the centre of the UK, varying slightly with location. Try to obtain an image of the full Moon as close to the start of the eclipse as possible (17:08 UT). The Moon's altitude will be 8 at this time. This is a safety control shot in case it clouds over later.

STEP 4

It pays to decide early on your imaging cadence, or how frequently you intend to take images during the penumbral eclipse. Unlike an umbral lunar eclipse, a penumbral eclipse doesn't show dramatic changes during the event. As a consequence, a shot every 15 or even 30 minutes should be sufficient to show the nature of the event.



STEP 5

If the weather is clear after the end of the eclipse (21:12 UT) this is the time to take the second control image of the uneclipsed Moon. If this image is successful, the earlier image can be discarded. The second image will have the advantage of appearing clearer due to higher altitude. If the weather is bad, use the first image.

STEP 6

To show the penumbra shadow darkening, layer and align an eclipsed image over a control image. For the 10 January event, select half the upper Moon image and delete. In our main image (opposite), the penumbra's orientation was darkest towards the northwest of the disc. On the 10th it'll be darkest at the south.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Separating stars from deep-sky objects

How to use PixInsight to enhance the brightness of a galaxy image without affecting the stars

Dealing with a high dynamic range and ensuring that the bright parts of deep-sky objects are not burnt out during image processing is an important part of the workflow. Typical examples of high dynamic range objects include galaxies such as the Andromeda Galaxy, and nebulae such as the Orion or Wizard (above). What is less obvious is the limit the stars themselves place on how far you can stretch an image's brightness before they become bloated. How useful would it be if you could remove the stars during this part of the image processing and then add them back in later on? Well, you can and here we will show you how to accomplish the task easily using PixInsight. As an added bonus, if you are imaging in narrowband, which often results in bland stars, you can use just the nicely coloured stars from an LRGB (Luminence, Red, Green and Blue) image of the same object as replacements.

▲ **The partially processed and stretched image of the Wizard Nebula**

ALL PICTURES STEVE RICHARDS

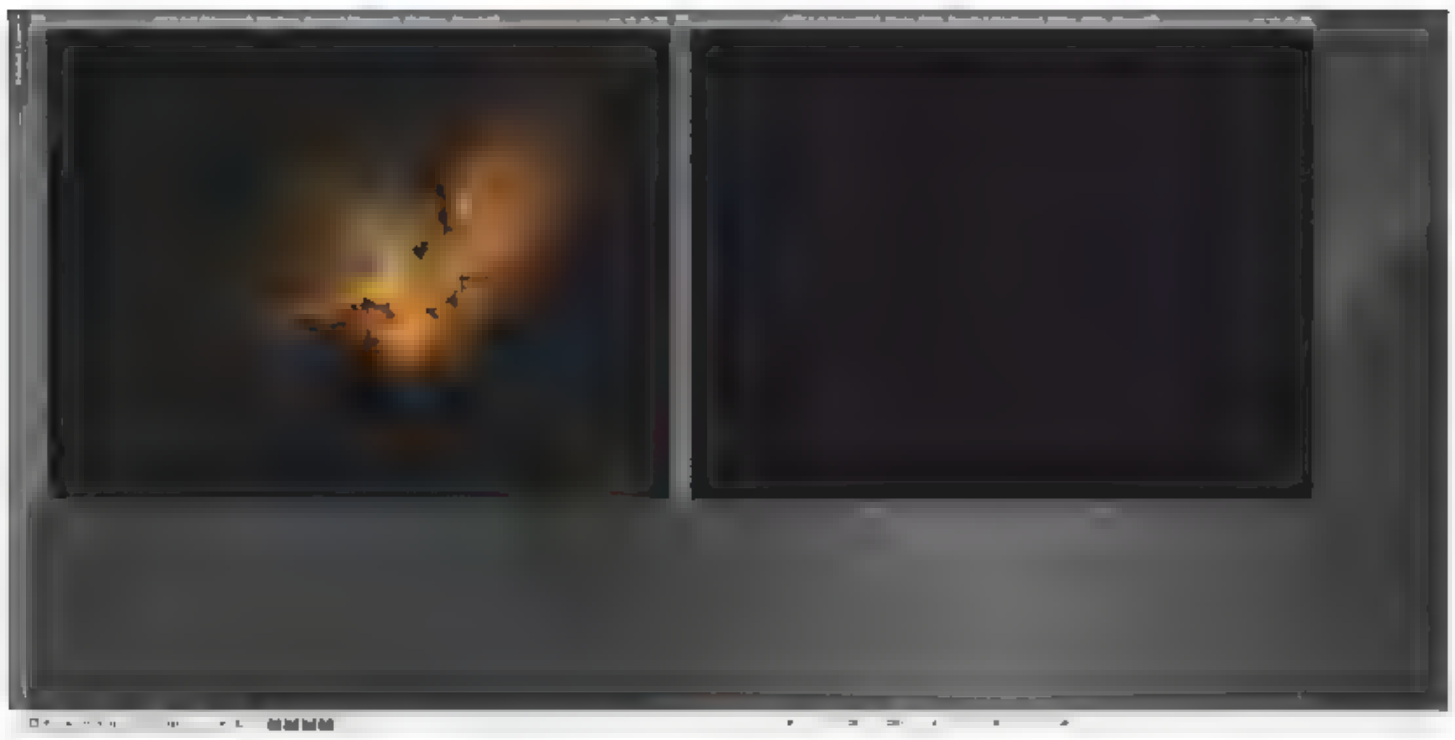
PixInsight is always evolving and a new process called StarNet++ is now available. This process is currently only available for the Windows version of PixInsight although Mac OS users can also download a stand-alone command line version. The PixInsight Windows version can be downloaded from **https://sourceforge.net/projects/starnet/files/PixInsight_module**

Star removal process

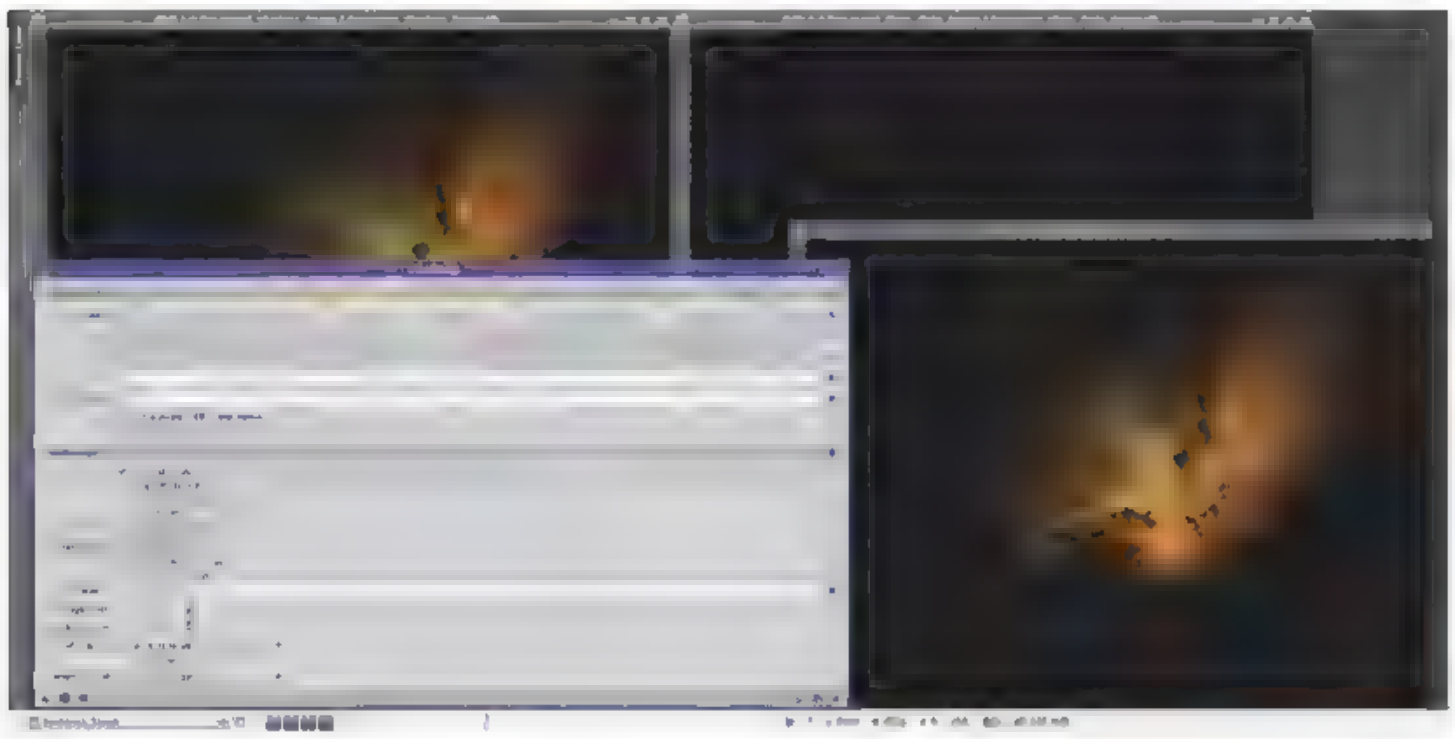
StarNet only works with non-linear images, in other words, those that have had at least a preliminary stretch carried out on them, so use HistogramTransformation (HT) by selecting Process › IntensityTransformations › HistogramTransformation to adjust the image. Select the 'Realtime Preview' button and use the shadows, mid-tones and highlights sliders to make an initial stretch adjustment to the preview image to bring out some detail and set your background level. Now, fix the new stretch on the main image by dragging the 'New Instance' button onto the image, then close HT. This image will be used to produce the 'starless' image, so produce a duplicate image for the 'stars only' image by dragging the image name tab onto the image itself to produce a clone.

To start the StarNet++ process, select Process › Etc › StarNet. The 'Stride' selector dropdown menu offers a

▲ **The stars are separated from the Wizard Nebula using the StarNet++ process**



▲ Once separated, the starless and stars-only images can be processed separately



▲ The PixelMath process is used for recombining the starless and stars-only images

range of processing tile sizes, but excellent results and a faster processing time can be achieved with this set to 128. StarNet++ has two modes of operation, star removal and star mask. To run the star removal process, untick the 'Create starmask' box, drag the 'New Instance' button onto the first image and watch the magic happen. To produce the stars only image, place a tick in the 'Create starmask' box and drag the 'New Instance' button onto the clone image. You now have two images, one with no stars and one with only stars. Now is a good time to save these two suitably named images, making it easy to identify which is which.

You can now process the starless image in any way you wish using any of the tools within PixInsight or any other image-processing software, like PhotoShop, to bring out the maximum amount of detail without having to worry about bloated or over-saturated stars. You can also work on the stars-only image to reduce their brightness and size ready for recombining with the main image to complete the project.

If you have both narrowband and LRGB image data for the same object available, you can use a suitably aligned LRGB image to extract naturally coloured stars for inclusion in a starless narrowband image using the same process.

There are various ways of recombining the starless and stars only images. PhotoShop's 'Screen' blend mode or PixInsight's PixelMath process – which is what we used here – both give excellent results. Select Process > PixelMath > PixelMath then place a tick in the 'Use a single RGB/K expression' and 'Generate output'. Activate the 'Create new image' radio button, enter a name for the finished image in the 'Image Id' box and leave all the other settings at their default values.

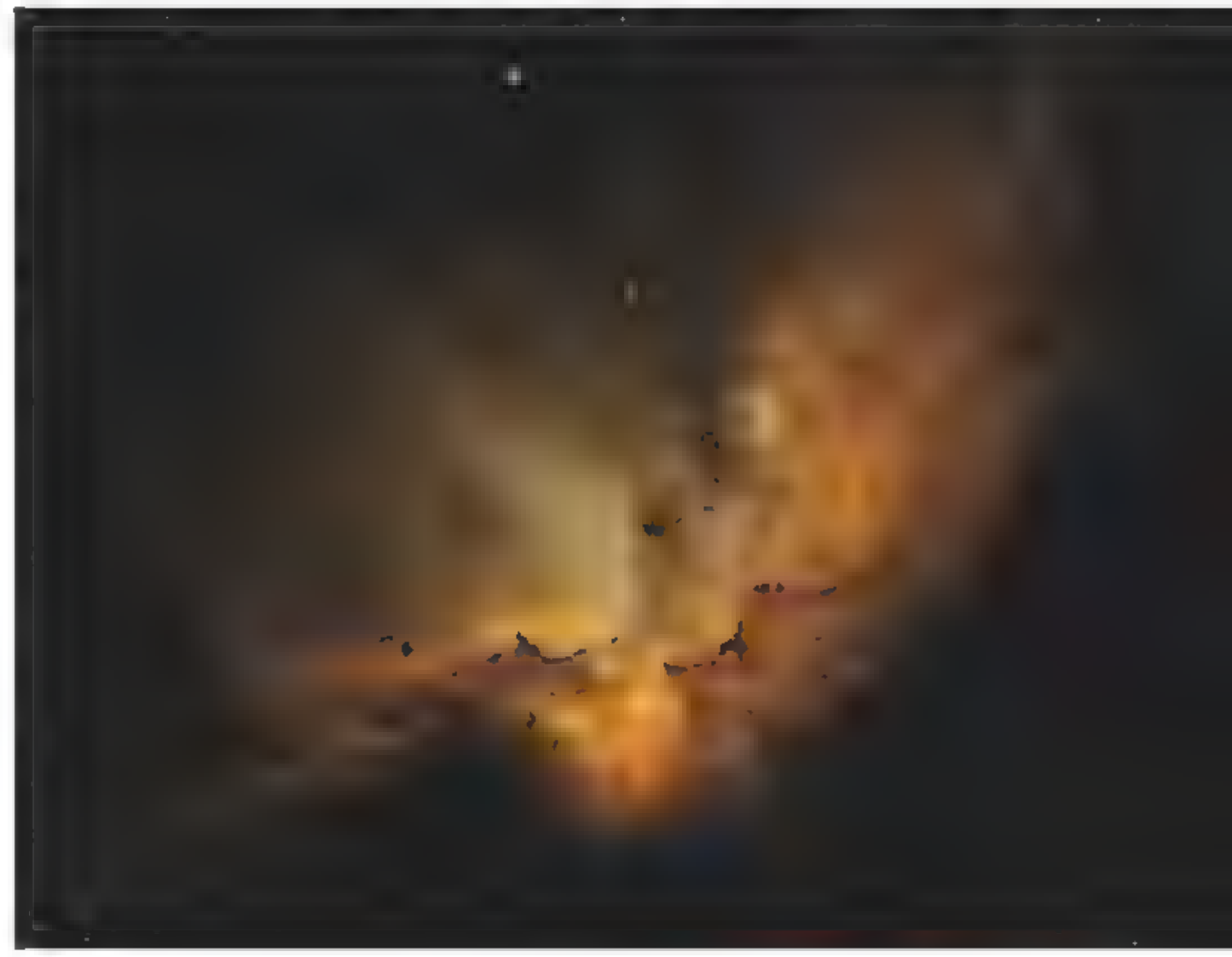
Click on the 'Expression Editor' button and type in the following two algorithms which maintain background levels and produce a 'screen' blend of the stars into the starless image:

iif((Stars_only_image_name <=0.01), Stars_only_image_name, 0.001); ~(~Starless_image_name * ~Stars_ only_image_name)

Replace the image names with the names of your own images selected from the list at the top right-hand corner of the Expression Editor dialogue box. Click on the 'OK' button to return to the PixelMath dialogue box then click on the the 'Apply (F5)' button to run the PixelMath process which will blend the two images together.

Steve Richards is author of *Making Every Photon Count: A Beginner's Guide to Deep Sky Astrophotography*

▼ The final Wizard Nebula image with the recombined stars



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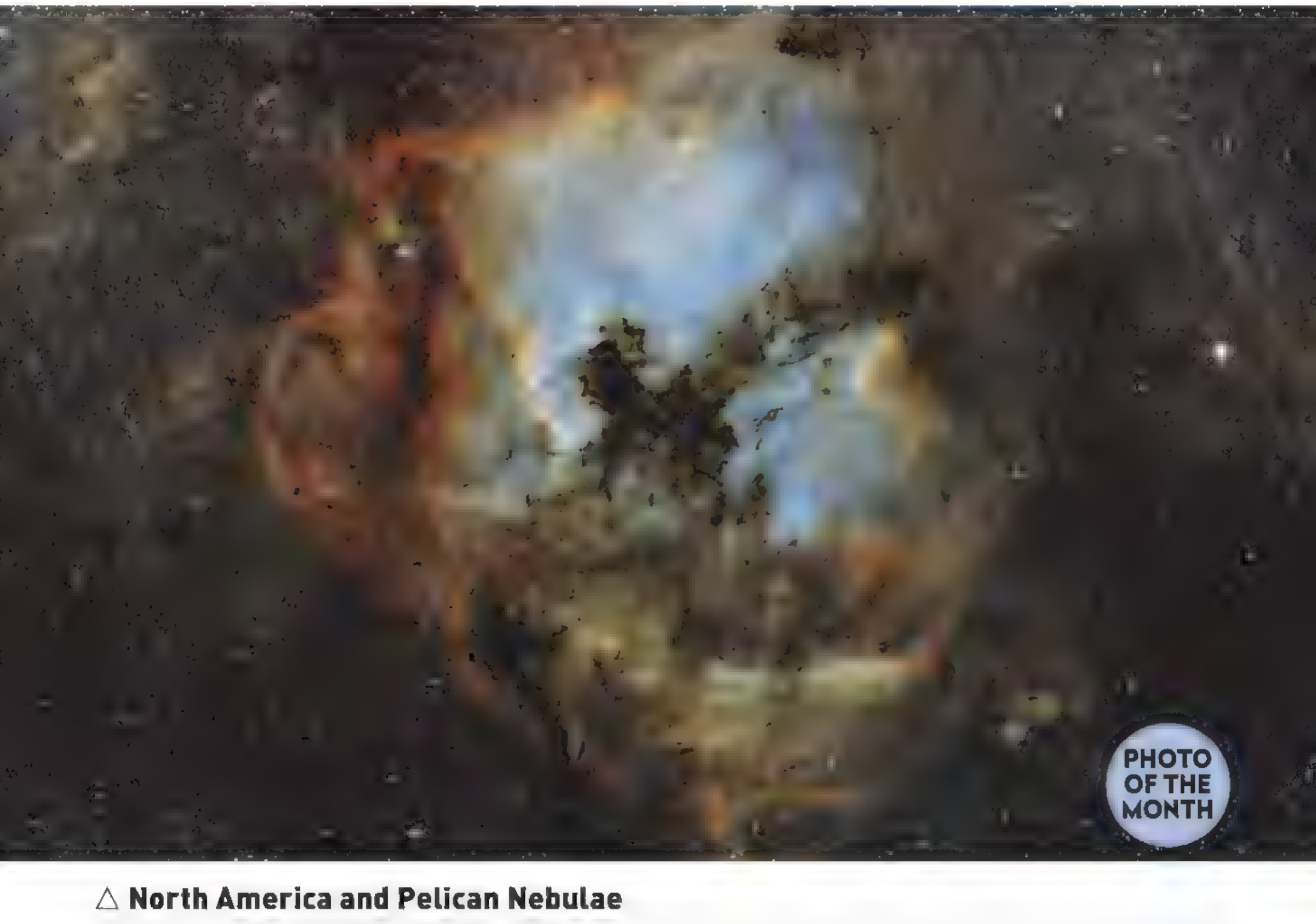


△ North America and Pelican Nebulae

Keith Bramley, Pilling, Lancashire, September & October 2019

Keith says: "This image has been a marathon: so few clear nights has made gathering data a real challenge. But I'm very pleased with the result. I find it fascinating that such an image can be produced from such a modest setup. The lens, a Samyang 135mm, was bought secondhand from eBay. Although cheap compared to large refractors, it can produce exceptionally sharp images across the field of view. This level of performance is normally only achieved with scopes that are 10 times the cost and more."

Equipment Atik 383L+ CCD camera, Sky-Watcher EQ6 mount
Exposure 102x300" Ha, 79x300" SII, 87x300" OIII
Software DeepSkyStacker, Photoshop

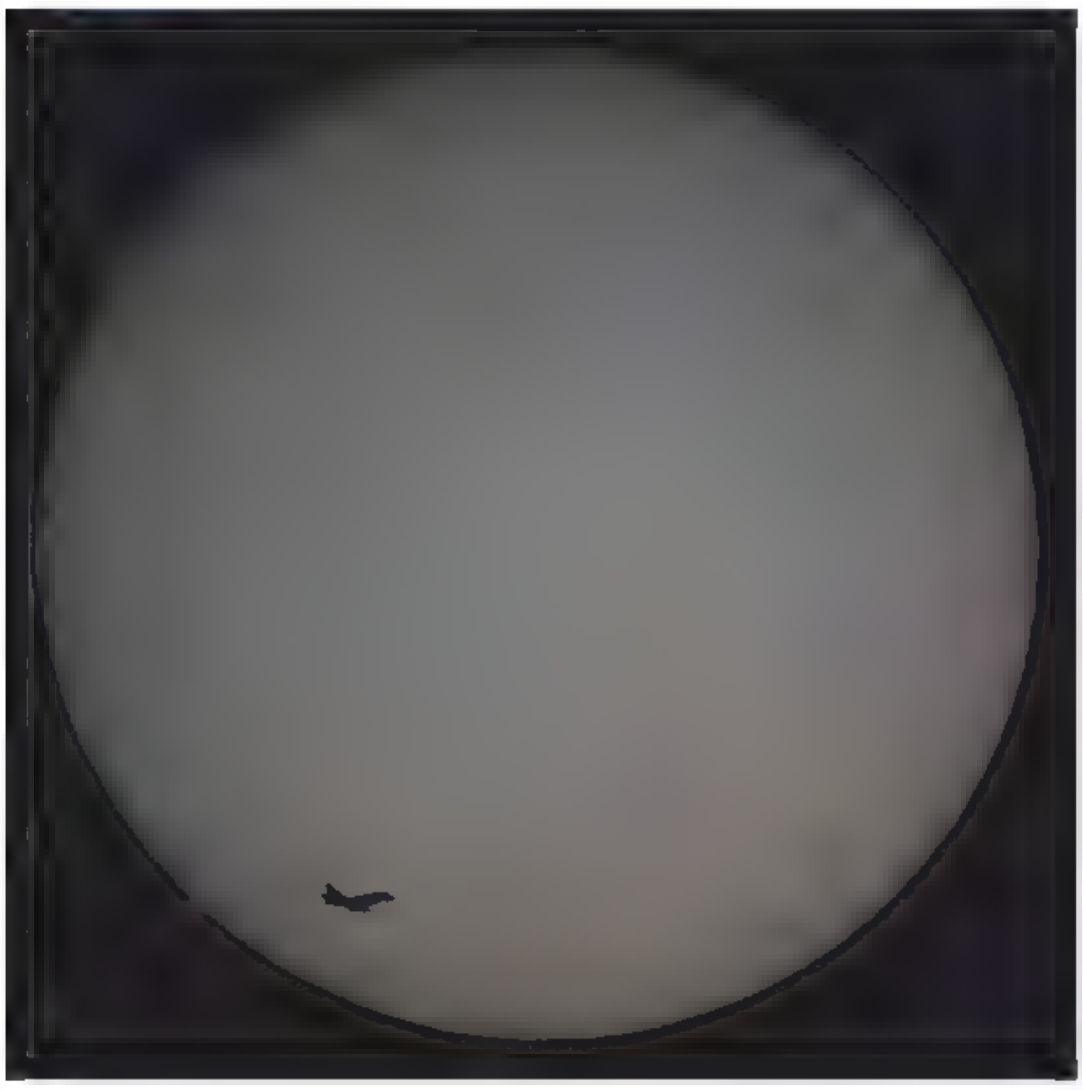
Keith's top tips: "A large, expensive scope is not required to take images of large nebulae like this, in fact a more affordable DSLR-type lens is better suited (eg a Samyang/Rokinon 135mm f/2). A dedicated cooled astro camera is recommended, but you can use a DSLR if it's been modified to allow Ha/SII light in. This is a colour-mapped image; monochrome narrowband data has been assigned to colours using the Hubble convention (SII is red, H-alpha is green, OIII is blue). Using the low noise H-alpha data as a final luminance layer improves the overall look of the image."

String of Pearls, NGC 55 ▷

Fernando Menezes, Brazil, June & July 2019

Fernando says: "NGC 55 is an irregular barred spiral galaxy and is believed to be very similar to the Large Magellanic Cloud (LMC), but turned sideways while the LMC is facing us. It is part of the Sculptor Group of galaxies. I chose this galaxy because of its irregularity and its striking features."

Equipment: QHY16200A mono CCD camera, Sky-Watcher Esprit 150ED apo triplet, iOptron CEM60-EC mount
Exposure: L 27x500", RGB each 49x300"
Software: PixInsight, Photoshop, PhotoScape



◁ Mercury transit

Neil Allen, Norwich, 11 November 2019

Neil says: "I had some great luck when a jet from RAF Lakenheath came across the Sun just as I took a photo of the Mercury transit. The photo was taken from my back garden in Sprowston, Norwich."

Equipment: iPhone 8, Sky-Watcher Equinox 80 apo refractor, TS Optics solar prism **Software:** iOS photo editor

Meteor moment ▷

Julie Winn, Hexham, Northumberland, 24 October 2019

Julie says: "I went out on to Hadrian's Wall near Hexham after work to see if I could shoot some aurora as there was a decent sun storm going on. I had been there about 15 minutes at 23:52 BST when suddenly the sky lit up behind me and this meteor flew straight over my head. I looked at my camera in hope that it was shooting and to my surprise I had caught it full on. I don't think I will be this lucky again."

Equipment: Nikon D3400 DSLR
Exposure: ISO 6,400, 13'
Software: Lightroom

△ Moon mosaic

Hugh Bellamy, Aberkenfig
21 September 2019

Hugh says 'Capturing the 30 images for the mosaic in the shortest time possible was a challenge as each one required enough good quality frames for stacking. Adjusting the exposure for the areas near the terminator and then the brighter areas to obtain a balanced dynamic range was another challenge. I was pleased with the outcome."

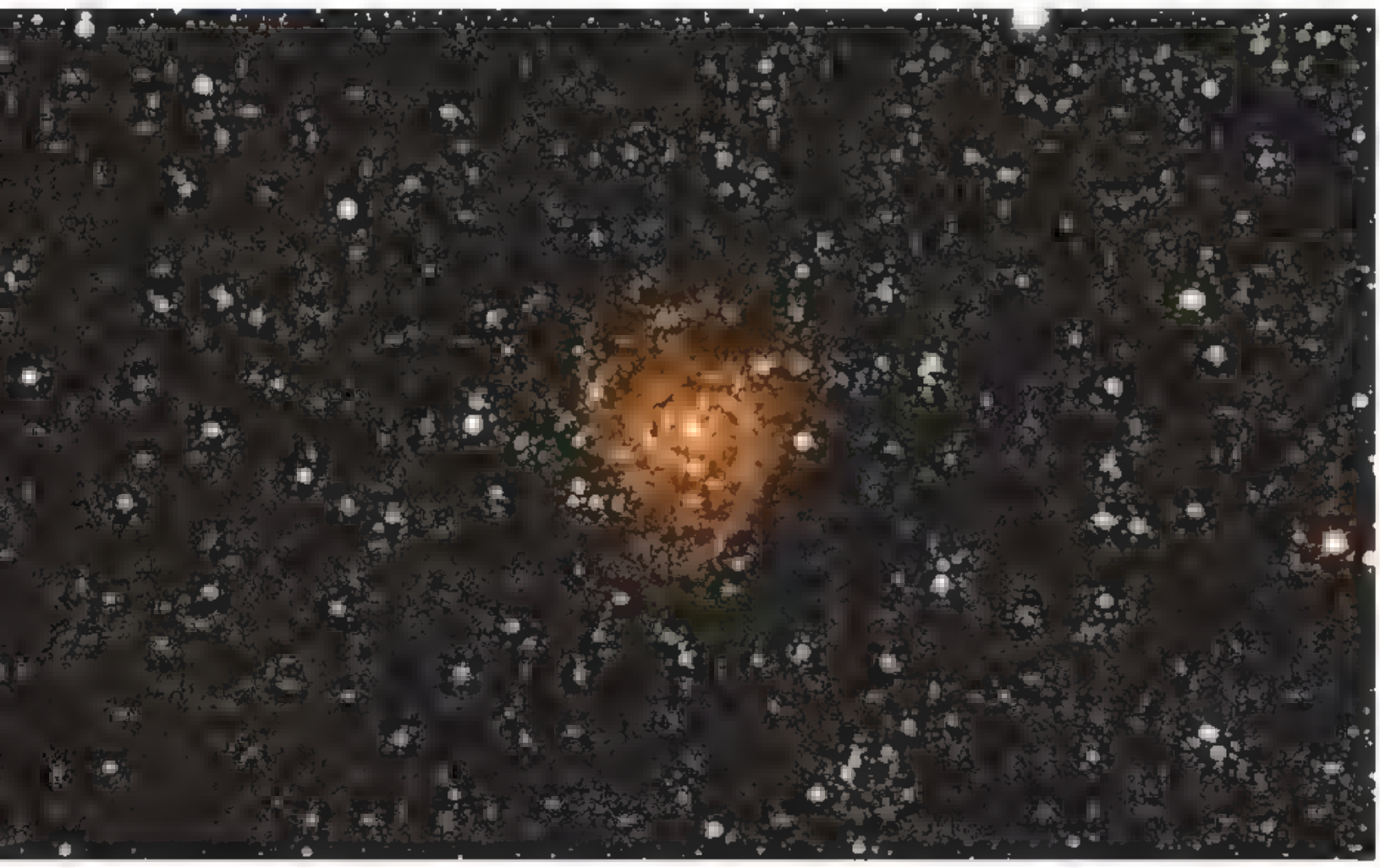
Equipment ZWO ASI 120MC camera, Sky-Watcher 254mm Newtonian, EQ6 Syntrek mount
Exposure: 30 panes, 2,000 frames per pane
Software RegiStax, Microsoft ICE, GIMP

◁ Uranus

Ralph Smyth, Lisburn, 24 October 2019

Ra ph says. "I set up with the intention of doing some deep-sky work, but I was curious to see if I could capture distant Uranus among the stars of Aries. To my delight, as well as imaging the greenish hue of the planet, I managed to pick up four of the main moons of the Uranus system."

Equipment: Nikon D5300 DSLR, Sky-Watcher Esprit 120ED refractor, Sky-Watcher EQ6-R Pro mount
Exposure. 5x120"
Software BackyardNIKON, Astro Pixel, Photoshop



◁ The Hidden Galaxy

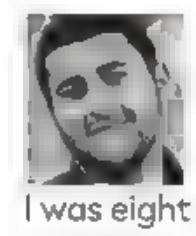
Jim Hunt, Alnwick, Northumberland, 26 October 2019

Jim says: "Being in the unusual situation (for me) of being at a dark-sky site (Bortle 3) with big open skies, I just couldn t decide what to image. So I looked to *BBC Sky at Night Magazine*'s October Deep-Sky Tour for inspiration. IC 342, the Hidden Galaxy, looked interesting so I thought I d give it a go. I wasn't expecting much, given we are seeing it through our own Galaxy, but I'm very pleased with the results. I think it's now worth adding more exposure time to improve the detail.'

Equipment: Altair 183c Pro Tec camera, Altair 72 EDF refractor, Sky-Watcher HEQ5 Pro mount
Exposure. 24x300'
Software: APT, PixInsight

◁ Milky Way

Abolfazl Arab, Sistan, Iran, 30 July 2019

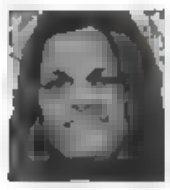


Abolfazl says:
"I've been fascinated by astronomy and the night sky since I was eight years old. The castle of Rostam, about 70km from the city of Zabol, has about 500 years of history and is one of the most famous historical monuments left in Sistan and Baluchestan province. The Milky Way is located vertically above the castle like this only in summer."

Equipment: Nikon D7200 DSLR
Exposure: ISO 2,500, 30'
Software: Photoshop, Lightroom

Venus at sunset ▷

Darshna Ladva, Mallorca, 16 October 2019



Darshna says:
"While I was on holiday, one evening Venus appeared bright and visible in the afterglow of the setting Sun. Mercury was also visible, albeit many times less bright and I can only faintly see it in my frames. I took my little telescope on holiday with me with the plan to catch moonrise, but I quickly imaged Venus as it was setting. The tower in the foreground is about 11km from our hotel."

Equipment: Nikon D5500 DSLR, Altair 60 EDF doublet refractor, Sky-Watcher Star Adventurer
Exposure: ISO 800, 9x1/10"
Software: Lightroom, Photoshop

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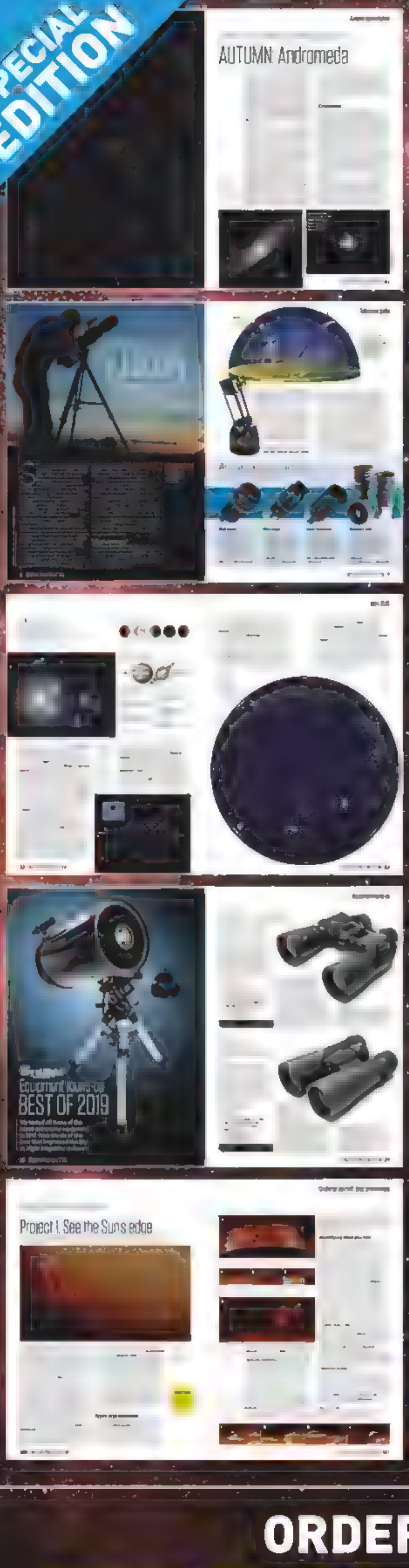

FROM THE MAKERS OF BBC Sky at Night MAGAZINE

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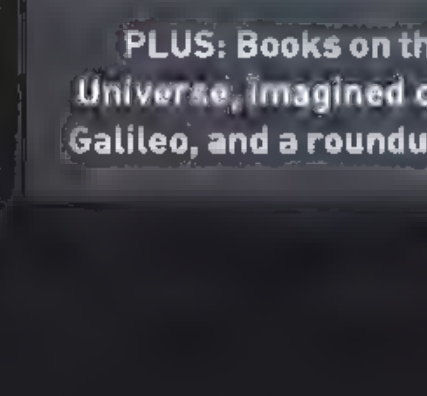
86



PLUS: Books on the history of the Universe, imagined conversations with Galileo, and a roundup of essential gear

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

Our experts review the latest kit

FIRST LIGHT

Celestron SkyMaster Pro 20x80 binoculars and 10Micron BM100 Leonardo mount

A perfect pairing that enables your binocular observing to move to the next level

WORDS: STEVE TONKIN

VITAL STATS

- **Price** £230 binoculars; £1,995 mount (tripod not included)
- **Optics** fully multi-coated
- **Aperture and magnification** 80mm, 20x
- **Prisms** BaK-4
- **Angular field of view** 3.2°
- **Focusing** centre focus
- **Height range of mount** 150cm
- **Mount load capacity** 13kg
- **Weight** 2.4kg binoculars; 13kg mount
- **Supplier** David Hinds Ltd
- **Tel** +44 (0)1525 852696
- **www.**dhinds.co.uk

ALL PICTURES WWW.THESECRETSTUDIO.NET

For those of us who enjoy visual observing, one of the unparalleled pleasures is using big binoculars on a decent parallelogram mount. Celestron's new SkyMaster Pro range of binoculars has an attractive array of specifications, and 10Micron has a reputation for well-implemented mounts. So, how do they pair up?

The SkyMaster Pro 20x80 binoculars have a Porro-prism centre-focus design, with the satisfyingly sturdy feel of substantial textured rubber armour covering the aluminium and polycarbonate body. The hinge, focus and right eyepiece adjustment all operate smoothly, with an appropriate amount of resistance so that they do not become unintentionally adjusted. As the objective caps are tethered securely they won't get lost, and they are immediately available to delay dewing should you take a break in observing. A unique feature is the interchangeable eye cups: you can choose normal or winged. The winged eye cups effectively shield your eyes from stray light, but they have to be folded down to get the rainguard-type lens caps on. Unfortunately, they have an annoying tendency to come off when you fold them back up again. In the body of the binoculars, the prisms are secured in a proper cage, not merely clipped to the housing. Further testing confirmed that the binoculars are not internally stopped down and they pass light from the full 80mm aperture to the eyepiece.

When you remove the Leonardo parallelogram mount from its box, the rigidity of construction and fine quality of finish immediately become apparent. We were delighted that a locking pin ensures there is none of the notorious finger-trapping parallelogram movement as you take it out. This locking mechanism is also useful when you are attaching the binoculars and counterweights.

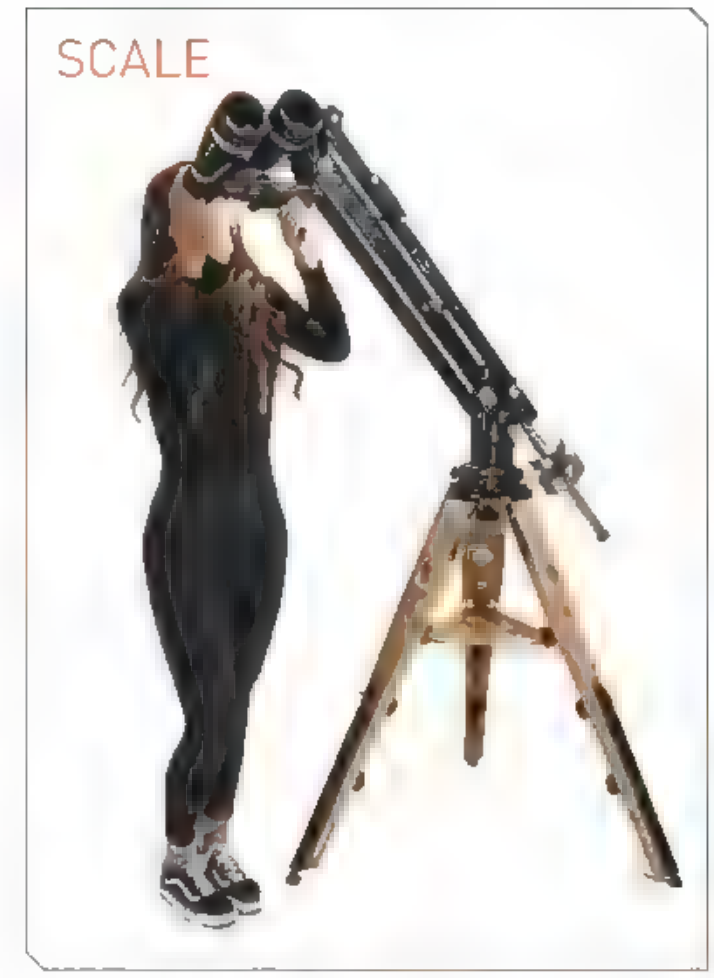
You first need to assemble the instrument platform, which attaches to a dovetail on the parallelogram. The short 30mm diameter counterweight bar screws into the tripod end of the parallelogram, its weight, augmented by double counter-balance springs in the parallelogram structure, helps to balance the load. You ▸

Crystal clear views

To get the clearest visual images from binoculars, you need good optics that are held rock steady. The SkyMaster Pro binoculars meet part of this requirement. The contrast between the background sky on one hand, and the light from stars, planets and deep sky objects on the other, is apparent all over the field, and especially so in the middle. The anti reflective coatings and well designed light baffles play their part very well. Of course, this would be wasted if the image was dancing over the sky, and here the mount has to earn its keep. With the BM100 Leonardo, you don't need to worry about 'the wobbles'. It has exceptional torsional rigidity and the relatively short counterweight bar all but eliminates the longitudinal oscillation that can sometimes plague long arm parallelograms. After acquiring your target object, you have little more than a second before the visual image is perfectly still, and the result is that you can push the binoculars to the best of their ability.

Adjustable instrument platform

Binocular mounts work best when the altitude fulcrum is aligned with the centre of mass of the binoculars. If it's not, they will become unbalanced as the target elevation changes. The slotted mounting holes on the instrument platform dovetail plate enable this adjustment to be made.



Adjustable height and azimuth friction

Low friction motions on a parallelogram mount give a sensation that the binoculars are floating in space, but this becomes inconvenient if you are using it in windy conditions or situations where the binoculars can easily be nudged. Your ability to increase the friction minimises the effect of these adversities.

Waterproof and nitrogen-filled

Dew is the bane of every binocular observer, but not only does it spoil your view of the heavens, it also potentially ruins your binoculars if it gets inside. Waterproofing is therefore a 'must-have' option for an astronomical binocular, and the addition of dry nitrogen filling will inhibit corrosion by oxidation.

*Tripod not included

FIRST LIGHT

KIT TO ADD

1. Geoptik Hercules 95 tripod

2. Celestron RSR with Celestron StarPointer Pro finderscope

3. Baader cleaning kit

▸ will need a substantial tripod or pier, and the package includes a very versatile base-adaptor plate. It is specifically designed for the 10Micron/Geoptik range of tripods (the supplier kindly loaned us a Geoptik Hercules 95) but the pre-drilled holes permit it to be used with other heavy-duty options, so we also tried it on an iOptron Tri-Pier. Both were rock steady.

In the balance

You can lock the parallelogram horizontally when you fit the binoculars and counterweights, and also gradually slacken the friction to achieve perfect balance as you adjust the counterweights. We found it easier to attach the binoculars with them pointing vertically, because the mounting screw (option of 1/4-inch or 3/8-inch) locking system on the mounting plate is activated by gravity. We needed to use both the 6kg and 3kg weights to balance the binoculars.

Once it is set up, it's a joy to use, and the exquisite engineering design of the mount becomes apparent. Everything operates smoothly and there are 'warm-touch' handles and knobs where you would want them. The binoculars gave a bright, contrasty image, that was crisp over the central half of the field of view and – other than obtrusive off-axis chromatic aberration on bright objects – was acceptable outside this except at the edge. The proximity of a first quarter Moon did not result in ghost images or spurious reflections.

The mount is specified for loads up to 13kg, so we also tried the heaviest binoculars we had available – 37x100s, weighing 6.5kg – which we augmented with a 4kg weight. The Leonardo handled this weightier model with ease. The SkyMaster Pro binoculars will suit someone who has exhausted the possibilities of an entry-level model and who wants a decent quality, large aperture instrument with the convenience of centre-focus. The Leonardo mount will suit this purpose and will be a future-proof option for anyone who may later upgrade to bigger binoculars who wants a substantial parallelogram that will last a lifetime.

VERDICT

Build & Design	★★★★½
Ease of Use	★★★★½
Features	★★★★★
Optics	★★★½
Stability	★★★★½
OVERALL	★★★★½

Finder rail

Mounted binoculars can be more difficult to aim than hand-held ones, especially when they have high magnification and, therefore, small fields of view. These binoculars are provided with a detachable rail on which you can mount a red dot finder (not included), making target acquisition a cinch.

Good stray light control

Celestron controls the scourge of stray light in two ways: the XLT multi-coatings increase light throughput and reduce the likelihood of internal reflections forming ghost images. The objective tubes also incorporate two light baffles, which effectively eliminate reflections off the tube interiors. The consequence is excellent image contrast.

ALL PICTURES WWW.THESECRETSTUDIO.NET

Our experts review the latest kit

FIRST LIGHT

QHYCCD QHY 168C

CMOS colour camera

A one-shot cooled camera that works well for planetary detail and deep-sky imaging

WORDS: PETE LAWRENCE

VITAL STATS

- **Price** £1,399
- **Sensor** IMX071 colour CMOS 14-bit (APS-C, 23.77x15.78mm, 28.53mm diagonal)
- **Pixel array** 4,952x3,288 (16 megapixels), 4.8x4.8micron square pixels
- **Exposure range** 30 microseconds to 3,600 seconds
- **Size** 105x90mm (supplied 2-inch M54/0.75 T-ring adaptor adds 35mm)
- **Backfocus** 18mm with 2-inch adaptor ring fitted
- **Weight** 450g
- **Supplier** Modern Astronomy
- **Tel** 020 8763 9953
- **www.modernastronomy.com**

ALL PICTURES WWW.THESECRETSTUDIO.NET

The QHY 168C from QHYCCD is a one-shot colour camera with an APS-C sized sensor, a size format commonly used in non-full-frame DSLRs. A built-in, two-stage Peltier thermoelectric cooling (TEC) system can bring the camera's sensor down to 35°C below the ambient (air) temperature, reducing thermal noise and, in theory, producing cleaner images.

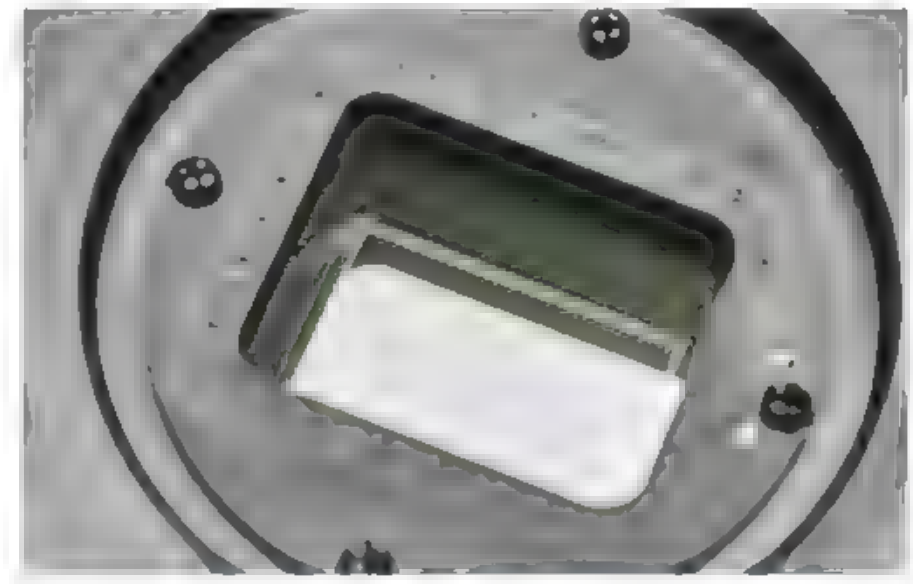
The QHY 168C uses a Sony IMX071 colour CMOS sensor, the same type as Nikon uses in several of its DSLR models. This chip provides a 16 megapixel array of 4.8 micron square pixels arranged in a 4,952x3,288 array. The camera uses an internal memory buffering system and, together with USB 3.0 connectivity, it's able to maintain high-speed PC transfer rates. In use the full-frame transfer time was quick enough that it didn't really register there was any delay. Recording natively as 14-bit images, it's possible to output 8- or 14-, or expanded 16-bit images from this camera.

Jack of all trades

Despite having a DSLR-class sensor, the QHY 168C offers far greater functionality than a regular DSLR. Exposure times range from 30 microseconds to 1 hour (3,600 seconds) and the camera supports region of interest (ROI) definition. ROI is used to define a smaller area of the imaging array as active, while pixels outside the area are ignored. As such, the camera is a jack of all trades when it comes to astrophotography, being both suited to wide-field deep-sky imaging, as well as the tiny fields used for imaging the planets.

The shorter end of the camera's exposure range permits 'lucky imaging'. Here, you basically take lots of images in rapid succession in the hope that some appear hardly distorted by the atmosphere. These are then extracted, registered and averaged together to give a result which should exceed the quality of an individual frame.

Obviously, using a large sensor like the IMX071 for lucky imaging at full resolution will take a toll on the number of frames per second you can record, the onboard memory buffer and USB 3.0 connectivity are efficient but still have limits on how much data you can convey to a PC. This is where ROI comes into its own, because a smaller active area results in a smaller ▸



Impressive sensor

The camera's Sony IMX071 sensor offers high sensitivity and low noise. The large APS C chip size is ideal for capturing wide deep sky images and offers up to 3x3 binning to improve light sensitivity, albeit at the expense of resolution and colour.

Colour sensitivity peaks around 525nm in green with both red and blue sensitivity peaks not far behind. Peak red sensitivity is around 605nm with the all important hydrogen alpha (656.3nm) response being around 80 per cent of the peak red value.

Full pixel well depth, the maximum amount of charge (electrons) a pixel site can store, is 46ke. Although typically most pixels in an astronomical image don't even get close to this value, it should be clear that the sensor's average readout noise of 3.2 electrons is very low in comparison. This is the noise introduced when a pixel's charge is converted to a voltage during readout.

We also detected no amp glow, even when the capture gain was set high. Amp glow is an effect where heat from components near the sensor can create an unwelcome glow along an edge or image corner.

Two-stage TEC cooling

The QHY 168C uses a two-stage Peltier cooling system to lower the sensor temperature down to a possible 35°C below ambient (air) temperature. Cooling is fast and maintains the selected temperature well. The sensor chamber is air-tight to prevent moisture getting in. Desiccant keeps the chamber moisture free with spare provided should replacement become necessary.

Camera image buffer

A buffer where image data can be stored en route to the host PC is provided by 128MB of internal DDR2 memory. This helps prevent bad frames caused by the computer should it unexpectedly pause the transfer. It also assists high frame-rate captures where the host's USB transfer rate is perhaps performing slower than desired.

Heated optical window

One problem with an efficient cooling system is fogging or even frost appearing on the optical window that fronts the sealed sensor cavity. The QHY 168C addresses this issue by providing an optical window heater. This raises the temperature of the window, dissipating any fogging or the unwanted build-up of ice crystals.

Rear connections

The QHY 168C connection ports are located on the rear of the camera body and are minimal, with just 12V power and a USB 3.0 port provided. A car-plug cable is provided with the camera, allowing you to power the 168C from your own 12V battery. A 1.5m USB 3.0 cable is also provided.

KIT TO ADD

1. Astronomik range of Luminance filters

2. The STC DUO filter in 2-inch/M48 size

3. QHY 020055 adaptor for 2-inch/M48 filters if there's no 2-inch nosepiece

▸ amount of data per image. For example, at full resolution, peak rates hit 10 frames per second but using a small 240x240 pixel array, this increases to 130 frames per second.

As is common with astronomically dedicated cameras, you are responsible for sourcing and installing control software to operate the QHY 168C. Fortunately, there are several free or low-cost options available. For our testing we used FireCapture and SharpCap. FireCapture is brilliant for high-speed captures, but less well-suited for long exposure astrophotography. SharpCap is a good all-rounder, V2.9 or above working well with the QHY 168C. An ASCOM driver is also available, allowing you to use the camera with any ASCOM-compliant applications.

Smooth operator

We found operating the camera using SharpCap to be intuitive and were imaging in no time. When we tested it on a bright deep-sky object such as the Orion Nebula, M42, we found it was easy to burn out the core of the nebula with just a few seconds of exposure using our test 4-inch (100mm), f/9 refractor. This high sensitivity is excellent if you need to keep exposures short. With longer exposures and a degree of light pollution, we were able to delve into the gas that inhabits the dimmer parts of the nebula with ease.

Turning our attention northeast towards the Horsehead Nebula, this proved a reasonable target for our 4-inch setup. The shape of the silhouetted horse's head was seen during test 60-second exposures. We also viewed a comet, C/2017 T2 PanSTARRS, which was close to the open cluster M36. The faint comet did register but was a bit lost in the wide-field coverage offered by the camera. A lucky imaging test capture of the Moon also confirmed that the QHY 168C is a great performer for Solar System imaging.

The QHY 168C is an excellent all-round colour camera. It offers superb sensitivity, wide-sky coverage with the appropriate optics and is easy to handle.

VERDICT

Build & design	★★★★½
Connectivity	★★★★
Ease of use	★★★★½
Features	★★★★½
Imaging quality	★★★★½
OVERALL	★★★★½

Adaptor ring

A 2-inch M54/0.75 T ring-adaptor is provided. This presents a standard 2-inch T-threaded barrel at the telescope end and a M54/0.75mm male thread towards the camera. An additional 'fast installation connector ring' is included. This locks onto the camera's forward collar via three thumb screws, presenting a female M54 thread into which the 2-inch adaptor screws.

◂ A waning gibbous Moon, as captured on the QHY 168C, using the high-speed capture program FireCapture

▾ The Horsehead Nebula, taken with the QHY 168C through a 4-inch (100mm) f/9 refractor, with 28 x 60-second images aligned and averaged

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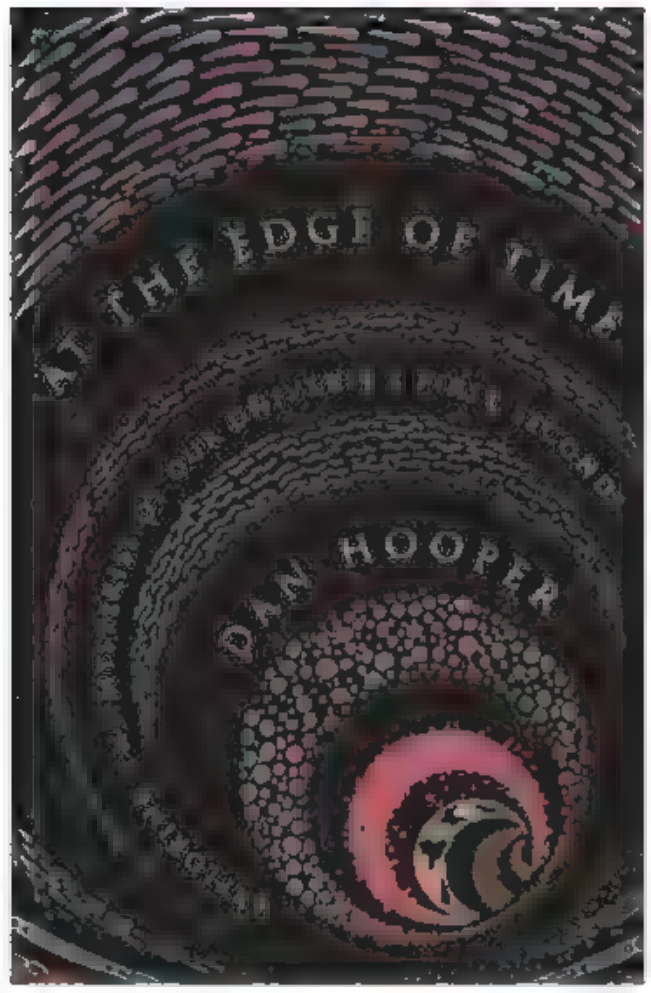


At the Edge of Time

Dan Hooper
Princeton
£22 ● HB

Cosmology, the study of the origin and evolution of the Universe, is by far one of the most fascinating subjects there is. Over the last century or so we've pieced together our own cosmic timeline, all the way from the Big Bang to the formation of galaxies. And yet it is still wonderfully incomplete, and we continue to be perplexed about the first fractions of a second of our Universe's history.

At the Edge of Time: Exploring the Mysteries of Our Universe's First Seconds investigates what we currently understand about our Universe and offers intriguing insights into the unknown.

What is dark matter? How did inflation occur? Why is there so much matter compared to antimatter in our Universe?

I really did enjoy reading *At The Edge of Time*, but it does take a bit of time to grow on you. Upon reading the poetic chapter titles and the first few pages, I thought "Here we go, a fairly standard way of opening a book centred around the Big Bang. Yawn." But as I turned the pages, I found myself getting wonderfully lost in this book, and swapping my usual pre-bedtime read for this. This is not something that has ever happened to me before with a popular science book!

Dan Hooper has an appreciably unique way of transporting the reader through our cosmic history. The book does not tell the story in the order I would expect; however the flow works beautifully.

There are several highlights for me. I love that the book does not shy away from controversial or tough concepts, such as MOND (Modified Newtonian Dynamics) theory, brane worlds and the anthropic principle. My favourite chapter describes some of the author's own work, in response to a friend asking what the author did day to day. However, my favourite takeaway from the book is the changing nature of the subject, and the excitement for the next scientific revolution that is likely needed for the next big breakthroughs. This is essential reading for any cosmology enthusiast – but if you're new to the area, be prepared for a bit of Googling. ★★★★★

▲ **What happened in the first seconds of our Universe?**

COFFEEKA/ISTOCK/GETTY IMAGES

***Dr Laura Nuttall** is a senior lecturer in gravitational waves in the Institute of Cosmology and Gravitation at the University of Portsmouth*

Interview with the author Dan Hooper

How is it possible to know what happened so soon after the Big Bang?

From a few seconds after the Big Bang to the present, we have a lot of observations and measurements to work with. But as we go back further into the first moments after the Big Bang we no longer have any direct observations to rely on. We have to recreate the conditions of the Big Bang in particle accelerators. In these machines, we study how matter and other forms of energy behave at high temperatures, such as were found throughout our Universe as early as a trillionth of a second after the Big Bang. We recreate a microcosm of the Big Bang here on Earth.

Could we ever know what happened before the Big Bang?

As we conventionally understand our Universe, there is no such thing as 'before' the Big Bang. Asking what happened before the Big Bang is like asking what lies north of the North Pole – there just isn't anything that those words in that order represent. In the traditional Big Bang framework, time along with space came into existence with the Big Bang.

Can we predict the Universe's end?

Yes, but we can't be sure that those predictions will turn out to be correct. From what we understand, it seems our Universe will expand forever. As this goes on, our Universe will become less dense and more cold. Ultimately, any usable energy will be exhausted, and our Universe will become cold and empty – a cosmic wasteland.

***Dan Hooper** is a professor of astronomy and astrophysics at the University of Chicago and head of the Theoretical Astrophysics Group at the Fermi National Accelerator Laboratory*

Conversations with Galileo

William R Shea
Watkins Publishing
£9.99 ● HB

Galileo pioneered the use of the telescope as a scientific instrument. His discovery of Jupiter's four largest moons and explanation of their motion as evidence of the heliocentric model was enough to earn him the label of 'scientific revolutionary'. But his fame goes far beyond this, thanks to his clash with the Catholic Church and resulting house arrest, making him a martyr to the cause of scientific truth.

The real story is more multifaceted than the simplistic science-vs-faith fable it's often portrayed as. The brief biographical sketch of Galileo at the start of this book shows some of the complexities of his entanglement with a powerful Church that both feared the new science and yet couldn't resist being involved with its development.

Like some of Galileo's own writings, the bulk of this book is constructed as a dialogue. The questions are framed by an unnamed narrator and at times feel a bit artificial. Likewise, Galileo is little more than a mouthpiece for the historical facts, never coming across as a fully rounded character. But when the facts are as fascinating as these, the book is still a good read and a useful starting point to the perennially important subject matter.

Short enough to read in one sitting, it's fully able to give us a hint of a society trying to come to terms with the emerging scientific revolution, and Dava Sobel's foreword is a lovely riff on Galileo's abilities to see the world anew in spite of his lifelong eyesight problems. ★★★★

***Pippa Goldschmidt** is an astronomy and science writer*

Rebel Star: Our Quest to Solve the Great Mysteries of the Sun

Colin Stuart
Michael O'Mara
£16.99 ● HB

It's become commonplace in popular astronomy to speak of the Sun as our local star, wielding huge influence over Earth and the rest of the Solar System. But the reality is that both amateur and professional astronomers, focused on the wonders and mysteries of deep space, all too often overlook the Sun and the lessons it can teach us about our Universe.

Stuart's fascinating new book sets out to put the record straight, looking at what we know about the huge ball of exploding gas at the centre of our Solar System, how we've reached our current state of understanding, and the many mysteries that the Sun still hides.

KEY RESOURCE

The book begins with a look at the history of our understanding of the Sun before the modern era, before moving on to tell the story of our star's origins and looking in detail at its various layers, its effect across the Solar System and its place in the Milky Way.

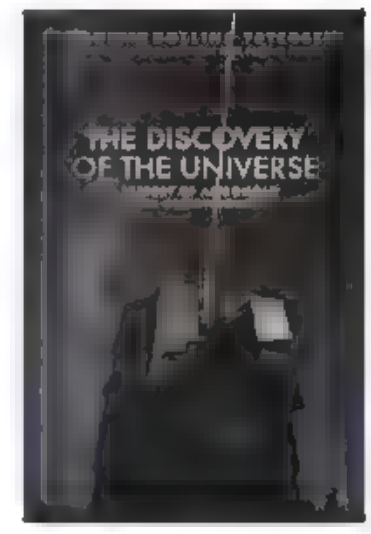
Along the way, Stuart tells stories of discovery, looks at the various Earth-based telescopes and space missions that have helped to establish the current picture, reviews unanswered questions and considers potential answers.

The writing combines a talent for describing the minutiae of solar physics with an engaging style and an eye for historical detail (we learn how a 1972 solar eruption derailed a US scheme to force a conclusion to the Vietnam War). All in all, a fascinating overview of an often-overlooked subject. ★★★★★

***Giles Sparrow** is a science writer and Royal Astronomical Society Fellow*

The Discovery of the Universe

Carolyn Collins Petersen
Amberley
£20 ● HB



Observatories are our eyes on the Universe – our "cosmos mariners", as Petersen calls them – without which humanity's voyages of discovery across space and time would be impossible.

It is surprising how few books tell the story of astronomy from the perspective of observatories. As a remedy, this book is a detailed, chronological history taking us through the great observatories from ancient history to the present.

We delve into the 'golden age of astronomy' in the 19th and 20th centuries, when observatories such as Yerkes and the Astrophysical Observatory of Potsdam became research laboratories in their own right. During this time, scientists endured inhospitable environments in search of clear, unpolluted skies, culminating in the space-based observatories of the past 60 years such as the Hubble Space Telescope.

The book is impressively up to date featuring recent key discoveries such as the 2019 image of M87's supermassive black hole, as well as a nod to future observatories soon to come online.

The narrative is, however, very densely written, and occasionally too focused on technical detail. The colourful characters and triumphs against adversity that pepper the story are only given a brief summary before the reader is whisked off to another observatory in another time place or wavelength. A more compelling narrative might have covered less ground, but with more elaboration on the cultural stories and astronomical significance of each example.

Nevertheless, the breadth and detail of this book makes it a useful reference for both professional and amateur astronomers, and a whistle-stop tour for those new to the field. ★★★

***Dr Tamela Maciel** is the space communications manager at the National Space Centre in Leicester*

Elizabeth Pearson rounds up the latest astronomical accessories

GEAR

1 IDAS RGB type 4 filters

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3 Constellation jumper

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This high-quality wool jumper is embroidered with stars and constellations, allowing you to show your love of astronomy while remaining stylish. Also available in infant sizes for the little astronomer in your life.

4 Celestron PowerTank lithium LT

Price £90 • **Supplier** Harrison Telescope
Tel 01322 403407 • **www.harrisontelescopes.co.uk**

Compact and lightweight, this rechargeable power pack can provide up to 8 hours of power. The PowerTank was specifically designed for astronomy use and delivers a steady 12V throughout its discharge.

5 Legami stars notebook

Price £8.95 • **Supplier** Executive Pens Direct
Tel 0203 371 0226 • **www.executivepensdirect.com**

This beautiful notebook, adorned with constellations, is the perfect place to record your astronomical observations. Comes with 164 lined pages, including 24 tear off pages at the back.

6 Astrozap flexible dew shield

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Tel 0203 8688042 • **www.astroshop.eu**

Keep dew at bay with the help of this dew shield. The main body acts as a barrier to dew, while the heating elements within keep your optics warm, preventing condensation from building up. The shield is supplied with a hook and loop fastener.

Shaoni Bhattacharya interviews Dr Joana S Oliveira

Q&A WITH A PLANETARY SCIENTIST

Mercury's magnetic poles have moved in mysterious ways – understanding them may help us with Earth's future

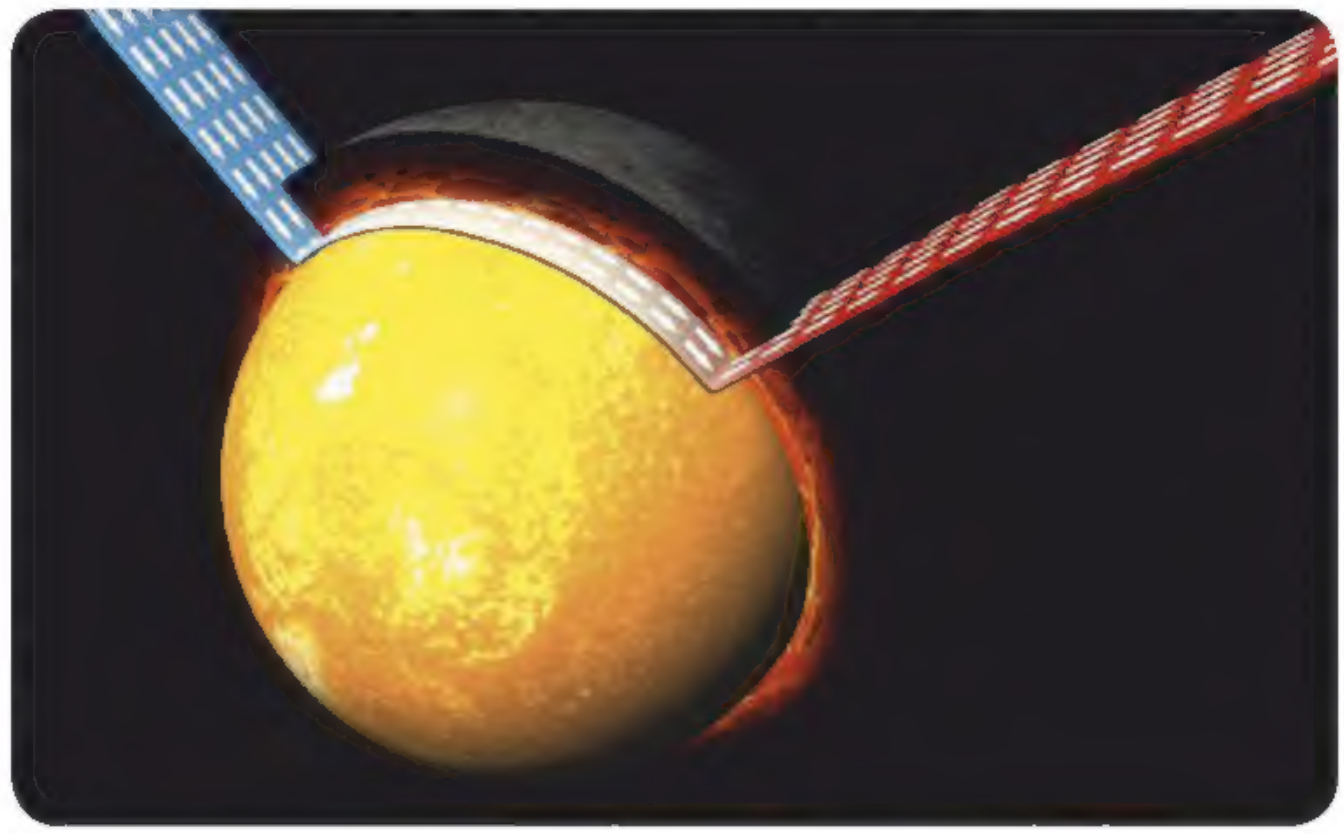
Why look at Mercury for magnetic fields and poles?
The terrestrial objects in our Solar System: the Moon, Venus, Mars – have no core magnetic field. The only other terrestrial planet apart from Earth that has a magnetic field generated by a dynamo process in its core is Mercury. What we observe on Mercury now we guess may be the future of the Earth's magnetic field – who knows?

What was the aim of your recent study into Mercury's magnetic fields?
We wanted to get an insight into the ancient core magnetic field of Mercury – it's like doing archaeology on planetary magnetic fields. The ancient core magnetic field is recorded in 'thermoremanent' magnetised rocks.

Imagine a swimming pool of molten material with magnetic material in it. Because it's very hot it cools down very slowly, so the little compounds of magnetic materials like iron metal will point to where the magnetic north pole was at the time. The molten material solidifies into thermoremanents and keeps that information forever.

What did you do?
I analysed data from the magnetometer of NASA's MESSENGER craft when it was at very low altitudes during its last 3-4 months. I looked only for signals related to craters to make sure that I got that pool of molten material that cooled down very slowly. The molten material takes millions of years to cool down and records the ambient magnetic field.

What was the main finding of your study?
For the first time I got information from the ancient core field of Mercury. Nobody has looked for that before. I got some palaeopole locations – previous magnetic north poles of past fields. If the field was a dipole parallel to the rotational axis, as it is on Earth, the palaeopoles would fall in the geographic poles, but this was not the case. The problem now is trying to understand what that means.



▲ **NASA's MESSENGER mission monitored Mercury's magnetic fields, revealing they flowed down (blue) and up (red)**

NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/CARNEGIE INSTITUTION OF WASHINGTON

How do you explain the unexpected locations of the ancient magnetic poles you found?
One hypothesis is that the magnetic field was not a dipole with only two ends, it was something else – a quadrupole, or an octopole. I tend to imagine a spaghetti dish, with field lines everywhere. The second hypothesis is that the magnetic field was dipolar but the crust of the planet has shifted, causing 'true polar wander'. The third theory is that a combination of both happened.

What does all this mean for Earth?
The main question is about how the Earth's magnetic field is going to be changing in the future, because we think it might flip direction. We have to look to other planets to understand this.

Several dynamo scientists are modelling the core dynamos of Earth and the other planets, but the physical processes of all terrestrial planets are similar. So by having different dynamo situations we can get more information on where Earth stands in those models.

Having a main dynamo model is very important to understanding our future. However, Earth's magnetic pole field inversions take a long time – 200,000 years on average. I don't think we need to be alarmed.

Dr Joana S Oliveira is a research fellow at ESA's European Space Research and Technology Centre in Noordwijk, The Netherlands, and an associate on the science working team of the BepiColombo mission

What do you hope that the next Mercury mission, BepiColombo, will do?
The ESA and JAXA (Japanese Aerospace Exploration Agency) mission BepiColombo launched in October 2018, and we have to wait six more years until it gets to Mercury. With MESSENGER we got zero magnetic information on Mercury's southern hemisphere. With this mission we will have measurements from all around the globe from two spacecraft simultaneously. It will allow us to separate the particles around the planet that produce some magnetic field from the core magnetic field. It's a big thing.

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Sirius and Canopus are prominent in the sky, and Mars and Jupiter are bright near the Moon

When to use this chart

1 Jan at 24:00 AEDT (13:00 UT)
15 Jan at 23:00 AEDT (12:00 UT)
31 Jan at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

JANUARY HIGHLIGHTS

The brighter planets have attractive conjunctions with the crescent Moon in January. As our satellite moves towards 'New', the eastern predawn sky on the 21st sees Mars 3° to the upper right of the 25-day old Moon. Two days later finds brilliant Jupiter, 4° to the lower right of the Moon, low in the eastern sky. The Moon then moves into the western evening twilight, meeting up with Venus on the 28th. This inner world will be only 3.5° to the lower right of the three-day old Moon.

STARS AND CONSTELLATIONS

The two brightest stars, Sirius (Alpha (α) Canis Majoris) and Canopus (Alpha (α) Carinae), are prominent in January evening skies. Although Sirius is the hotter of the two, the star is only the top dog because it's close by. Canopus is 35 times more distant, but a rare supergiant star with a luminosity 16,000 times greater than the Sun and an extraordinarily large surface area. Sirius is only 26 times the luminosity and twice the size of the Sun.

THE PLANETS

Evenings are now a little slow with one bright exception – Venus continues to dominate the western sky. Neptune is getting lower but before dropping into the twilight glow it passes Venus, being closest on 27th, only 0.5° apart. Uranus is now an evening only object, setting around midnight mid-January. Turning to the morning, Mars is low in the predawn eastern sky. Jupiter and Saturn return in January's last week, with Saturn 10° below Jupiter in early dawn skies.

DEEP-SKY OBJECTS

In the northeast corner of Puppis lies an isolated, mag. +4.7 yellow star, 19 Puppis (RA 8hr 11.3m, dec. –12° 56'). This is an attractive multiple star with two other obvious members, approximately 1 arcminute from 19 Puppis. These nearly matched 9th magnitude companions are only a few arcseconds apart. The star is on the edge of a bright (mag. +6.5) open star cluster, NGC 2539, showing around 80 9th magnitude stars arranged in curved lines with scattered clumps – impressive!

Move 8° west to another open cluster, Melotte 71 (RA 7hr 37.5m, dec. –12° 04'). In contrast to NGC 2539, the stars are fainter (11th magnitude) and more evenly dispersed with a slight concentration towards the centre. There is a scattering of brighter members at the edges as it blends into a star-rich Milky Way field.

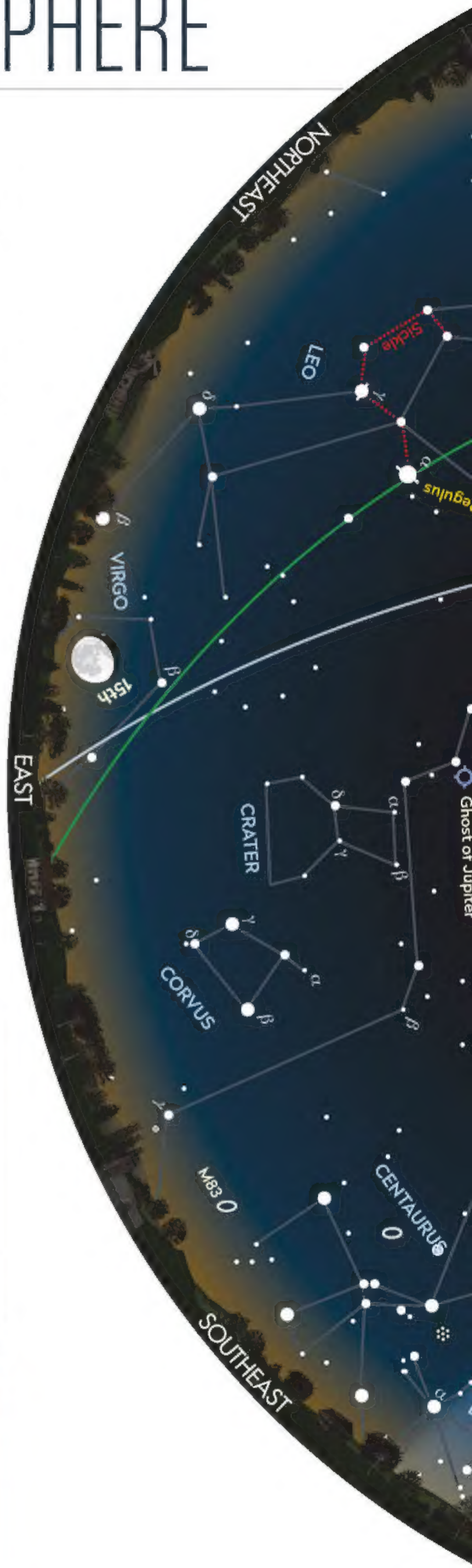
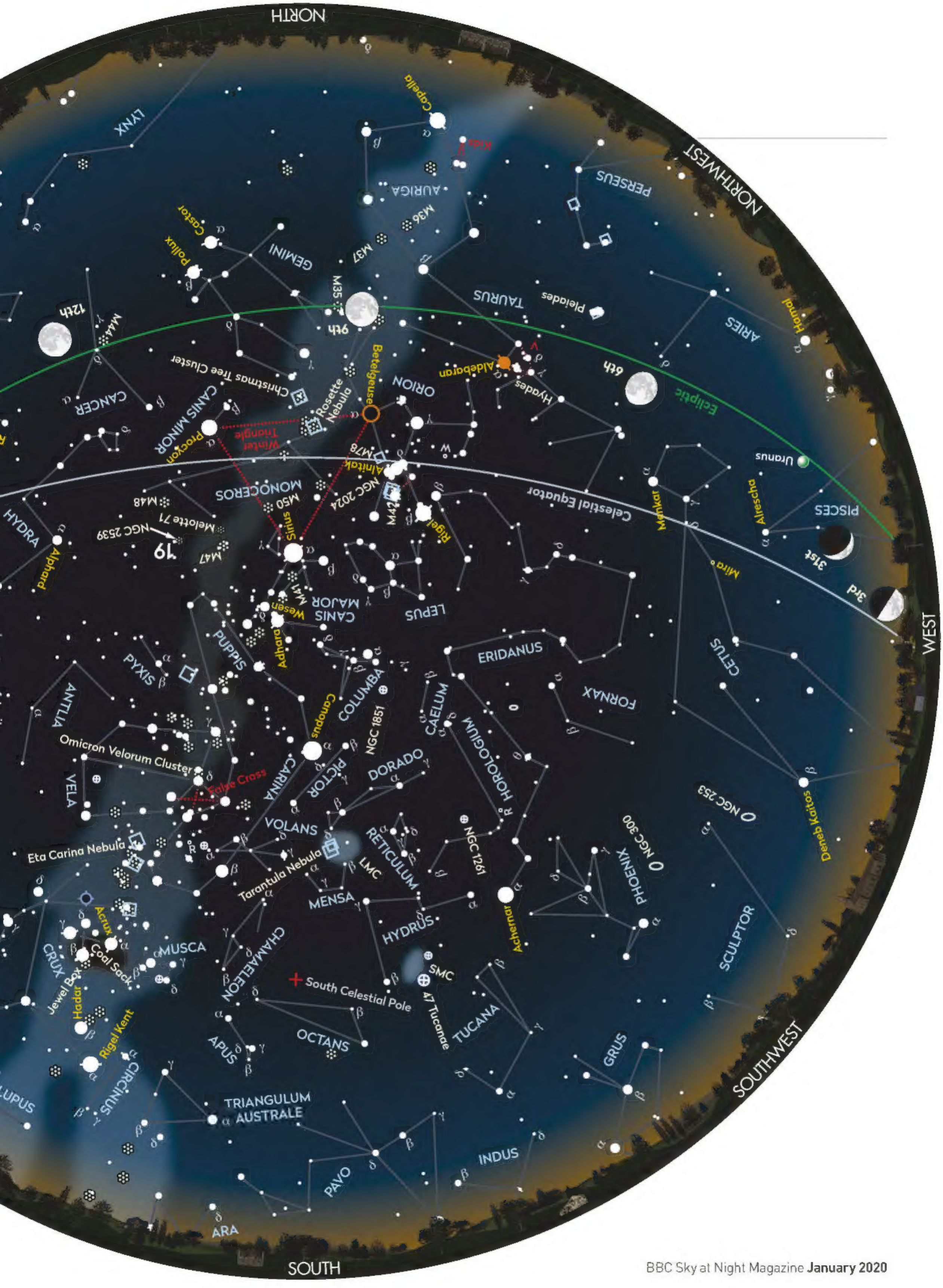


CHART: PETE LAWRENCE


NORTH
NORTHWEST
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SOUTH
LYNX
Capella
Kids
AURIGA
M36
M37
PERSEUS
GEMINI
Castor
Pollux
M35
9th
12th
M44
Pleiades
TAURUS
ARIES
Hamal
6th
Aldebaran
Hyades
Ecliptic
Christmas Tree Cluster
Rosette Nebula
Betelgeuse
ORION
CANCER
CANIS MINOR
Procyon
Winter Triangle
M78
Alnitak
NGC 2024
M42
Rigel
MONOCEROS
M50
M48
Sirius
Celestial Equator
Menkar
Uranus
Alrescha
PISCES
31st
3rd
Mira
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Alphard
Melotte 71
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M41
LEPUS
CANIS MAJOR
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ANTLIA
Omicron Velorum Cluster
False Cross
VELA
CARINA
Canopus
COLUMBA
NGC 1851
PICTOR
DORADO
VOLANS
Eta Carina Nebula
Tarantula Nebula
LMC
RETICULUM
MENSA
HYDRUS
NGC 1261
CAELUM
HOROLOGIUM
ERIDANUS
FORNAX
CETUS
Achernar
PHOENIX
NGC 300
NGC 253
Deneb Kaitos
SCULPTOR
Coal Sack
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